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DILLON RESOURCE AREA
RESOURCES INVENTORY:

WATER QUALITY SURVEY
TENDRY UNIT

November 30, 1978

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INTRODUCTION

Watershed managers have traditionally been concerned with the quality of the waters that leave a watershed. As man modifies watersheds by various land use practices, disequilibrium in both the terrestrial and aquatic environments occurs. Problems result in controlling accelerated sediment and nutrient release from non-point sources within the basin. Stream water samples provide the investigator with insights into the general health of the patient. In an attempt to reduce watershed degradation, Congress recently mandated that local and regional agencies and authorities gather and assess environmental data for the lands and waters under their jurisdiction and authority. The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92M-500) was promulgated to require:

- 1) the assessment of the sources and extent of non-point pollution, and
- 2) the development of methods and procedures for controlling non-point pollution resulting from agricultural and silvicultural activities (FWPCAA, 1972).

In April, 1976, personnel from the Montana Forest and Conservation Experiment Station began a resource inventory in southwest Montana for the Bureau of Land Management. This integrated resources inventory was designed by Bureau personnel to provide environmental data on watershed, wildlife, and range resources within portions of Beaverhead, Deer Lodge, Madison and Silver Bow counties near Dillon, Montana. More specifically, the National Resource Lands in the Rochester, Blacktail, Tendoy Mountains, Dillon West, and Centennial Planning Units were inventoried. The environmental data obtained is to be incorporated into the Bureau's

Planning System and into the Mountain Foothills Range Environmental Impact Statement.

The water quality study of the above resource inventory project included the monitoring of 42 temporary stream sampling stations located in 16 drainage basins within the inventory area. Stream discharge, suspended sediment, hydrochemical values and coliform counts were monitored at each sampling station for the 1977 and 1978 hydrologic years. In addition, the macrobenthic invertebrate communities at each station were sampled, the results of which were reported elsewhere. This volume presents the results of the water quality study for the Tendoy Planning Unit which includes Big Sheep and Muddy Creeks.

METHOD

The basic experimental design of the water quality study, developed by Bureau personnel, includes the sampling scheme, field methods, and laboratory methods. Minor additions and modifications to the original design were subsequently incorporated into the study as field and laboratory conditions dictated or permitted. Specific comments on such alterations are included.

Inventory Design

The initial phase of the water quality study involved a stream reach inventory and channel stability evaluation of each designated stream reach. The method and procedures used during this evaluation are outlined in Pfankuch (1975). The stream reach ratings were completed during August and September, 1976.

The 42 stream sampling stations were established during September, 1976. The selection of each gaging station site was governed by criteria presented in Carter and Davidian (1968). Each stream sampling station included a staff gage, a crest-stage gage, and a max-min thermometer. A standard 3.3ft. staff gage was mounted to a fence post driven into the stream bed. A crest-stage gage was constructed of 3/4" diameter clear acrylic tubing, using modifications of the plans set forth in Buchanan and Somers (1968). This gage was affixed to the staff gage and fence post. The max-min thermometer was bolted within a piece of PVC pipe, laid on the stream bottom, and attached by a chain to a fence post.

In addition, a 15 unit precipitation gage network was established in the spring of 1977. A general purpose rain gage (forester type) was installed in a plywood frame at each designated sample location and placed in a clear, open site at a 12" height above ground level. This technique

conforms with that recommended by the World Meteorological Organization (World Meteorological Organization, 1969, as cited in Aldridge, 1976). Such a placement minimizes the error caused by wind eddying (Stringer, 1972, p. 29; Aldridge, 1976), and reduces the probability of disturbance or damage by livestock or vandals.

The stream and precipitation gage networks were monitored during the 1977 and 1978 hydrologic years. The basic design called for all stations to be visited on a prescribed schedule of weekly during peak runoff and monthly during low flow. The field seasons included: October - November, 1976; February and April - November, 1977; and March - September, 1978. The following water quality parameters were monitored as applicable. During each visit; stream discharge, suspended sediment, specific conductance, air temperature, water temperature, max-min water temperature, and precipitation were determined. Once a month, a water quality sample was taken for the following analyses: pH, alkalinity, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, ammonia, nitrite-nitrate, and ortho-phosphate. A second stream water sample was obtained for bacterial analysis to determine levels of total and fecal coliform.

Macroinvertebrate inventories were also conducted at each stream sampling station during May, July, and September of each hydrologic year. Four individual square foot samples for the smaller streams and 6 samples for the larger streams were obtained during 1977, while 2 and 4 samples respectively were obtained for the streams during 1978.

Field Methods

Discharge values were determined by standard techniques using procedures described in Buchanan and Somers (1968). Stream velocities

were taken with a Gurley Pygmy type model 625 current meter. Sediment samples were obtained with a US DH-48 sediment sampler in conformance with procedures in Guy and Norman (1970). Water temperatures were recorded from Taylor max-min thermometers. Precipitation was collected in standard 7" rain gage (forester type). Specific conductance was measured with a Delta Scientific Model 1914 conductivity meter. Hydrochemical samples were collected in acid washed polyethylene liter bottles, which were filled to exclude air, and stored in an ice chest during transport to the laboratory. Microbiological samples were collected in 250 ml sterilized glass bottles and also stored in the ice chest. The macrobenthic invertebrate samples were taken with a Kahlsico stream-bed fauna sampler.

Laboratory Methods

Immediately upon arrival at the Dillon laboratory, each sample bottle was opened and an unfiltered sample was analyzed for pH and alkalinity respectively. The values obtained closely represent the values at the time of collection in the field (Brown, Skougstad, and Fishman, 1970, p. 129), while minimizing the potential for instrument damage during transport or carriage over back country roads or trails. This method has been adopted by several USDA Forest Service personnel (Aubertin, 1974; Snyder, et al., 1975). PH was measured using an Orion pH probe and an Orion 407 ion analyser. Akalinity was then determined by potentiometric titration to a preselected end point with a standard acid, as outlined in Brown, et al., (1970).

A 100 milliliter aliquot for ammonia analysis was then acidified with 0.8 milliliter concentrated sulfuric acid and refrigerated (American

Public Health Assoc., 1976, p.42). The remainder of each stream sample was subsequently filtered through a $0.45\ \mu\text{m}$ (micrometer) membrane filter and frozen. Membrane filters were soaked for 24 hours before using to remove any traces of soluble phosphate or nitrate (A.P.H.A., 1976 p. 472). Ammonia samples were analyzed on an Orion Ammonia electrode, model 95-10 (Orion Research Incorp., 1974). This analysis was routinely preformed in the Dillon laboratory on the final day of field collection.

Upon return to the Missoula laboratory the frozen samples were defrosted for analysis in the following order; 1) filterable orthophosphate; 2) nitrite-nitrate; 3) sulfate; and 4) common metals. Procedures followed were adapted from Standard Methods for the Examination of Water and Wastewaters (A.P.H.A, 1976), with the exception of nitrate which was taken from Methods for Chemical Analysis of Water and Wastes (Environmental Protection Agency, 1976). All colorimetric tests were preformed on a dual beam spectrophotometer (Beckmann ACTA model III). All glassware was acid washed.

The Asorbic Acid method, procedure 425F, (A.P.H.A., 1976) was used for dissolved orthophosphate. Results are expressed as $\text{PO}_4\text{-P}$. Nitrite and nitrate were determined collectively since nitrite usually occurs in insignificant amounts in uncontaminated surface waters. The sum of the two represents total oxidized nitrogen and is expresses as nitrite plus nitrate-nitrogen. The Cadmium Reduction Method (E.P.A., 1976) was selected because of its low detection limits ($10\ \mu\text{g/l}$). Sulfate was measured using the turbidimetric method, procedure 427C, (A.P.H.A., 1976). During the 1977 field season measurements were made on a spectrophotometer, but during 1978 a nephelometer (Turner Designs, Inc., medel #40) was used. Both

methods are recommended in the procedure, although it was found the nephelometer increased the precision of the test. Sodium, potassium, magnesium and calcium were run in that order by atomic absorption spectroscopy (A.P.H.A., 1976) using a Varian Techtron AA-5 spectrophotometer. Lanthanum chloride solution was added to the samples for magnesium and calcium analyses to prevent anionic interferences (EPA, 1976). Total dissolved solids and bicarbonate concentrations were determined from specific conductance and alkalinity values using calculations presented in Brown, et al., (1970).

Nitrogen levels, ie. ammonia and nitrite-nitrate, are consistently at the minimum detection limit of the analysis. Ammonia levels are particularly suspect owing to the limitations of the instrument and the technique for the analysis. In interpreting results of ammonia analysis; a presence or absence of detectable ammonia approach should be used. Thus high levels of ammonia indicate that a source of ammonia is present in addition to those which are naturally occurring. Such levels are usually transitory and may vary in order of magnitude. Nitrite - nitrate values are also near the minimum detection limit; however, the nature of this analysis yields more precise results. These values, as a whole, tend to be generally lower than those expected under the environmental conditions encountered. Low phosphate values are to be expected and were confirmed by this study. The method for phosphate analysis selected is the procedure generally used when working in this low range of values. The other ions, ie. sulfate and the common metals, tended to be present in sufficient quantities so that no problems were encountered owing to the sensitivity of the analyses.

Water samples for microbiological examination were analyzed within six hours of collection (Millipore, 1975a). Fecal coliform were cultured, identified, and enumerated throughout the study by the membrane filter method described by Millipore (1975b). Total coliform bacteria were cultured,

identified, and enumerated by the membrane filter method (Millipore, 1975a), but with the modifications outlined below.

Total coliform data for 1977 were determined by counting the number of wet colonies that exhibited a visible green metallic sheen, either to the naked eye or at 1.5x magnification. Millipore (1975a) recommends the use of a 10x magnification dissecting microscope and that the colonies be dry. Geldreich (1975), however, indicates that there is no significant advantage to drying the colonies before counting. Without the 10x magnification, however it is probable that colonies growing close together were mistaken as being one colony, and colonies having a weak metallic sheen were not counted at all. This procedure would result in data that would underestimate the number of total coliform colonies present.

A modification of the membrane filter method was adopted in 1978 to minimize the problem of underestimating the total coliform colonies. In the previous year, only the wet colonies exhibiting a distinct green metallic sheen were designated as coliform bacteria (Millipore, 1975a), while those wet colonies having a "non-sheen" red color darker than the medium-permeated background had not been counted. The degree of pigmentation and sheen development of coliform colonies grown on M-Endo medium, however, is variable according to both species and biotype. Furthermore, the identification criteria, i.e. colonies having a green iridescence or metallic sheen, is highly subjective and may vary from technician to technician. Thus, some authors admit that "questionable colonies" may occur which need more technical procedures for verification. One such procedure is to inoculate questionable colonies into a lactose broth, incubate at 35°C. for 48 hours, and determine whether gas and acid have been produced (Geldreich, 1975).

Using the above technique, an estimate of the fraction of questionable colonies was determined for which the lactose test was positive. After testing a series of 26 non-sheen, red colonies representing a variety of recognizable colonial morphotypes from several different stations, 69 percent were found to be lactose positive within 48 hours. Additionally, 16 percent of all dark red colonies found on 369 membrane filter samples exhibited a characteristic green sheen. It was thus estimated that approximately 75 percent of all red colonies darker than their membrane filter background conformed to either the green-sheen or lactose-test definitions of coliform bacteria. During the 1978 field season, all red colonies, sheen and non-sheen darker than their membrane filter background that were detected with the use of 10x magnification dissecting microscope were counted as total coliform. This procedure had the potential of overestimating the bacterial count by approximately 30 percent. It should be emphasized, however, that bacterial counts are not absolute values, but only estimates of magnitudes. Geldreich (1966, p.35) evaluated the total coliform bacteria for 40 samples using both the membrane filter method and the "most probable number" method. The ratio of their results varied from a minimum of 0.42 to a maximum of 2.52 respectively.

Tabulated total and fecal coliform data for this study are expressed as arithmetic means of either two or three replicated subsamples. Although the total coliform levels for the 1977 field season, i.e. May through November, 1977, are underestimated, the fecal coliform data for the two years are commensurate.

Analytical Methods

Stream discharge values were determined from field data with the use of a computer program based upon the procedure outlined in Buchanan and Somers (1969). These measured discharge values were then used to generate a staff-discharge rating curve for each station using a linear regression program. In several instances, two rating curves were produced. Instant and crest stage discharge values for the two water years were then estimated from the respective staff-discharge rating curves.

The annual hydrograph and sediment loading graphs were plotted with a computer using field data. Missing data points, i.e. winter months, were estimated using available stream flow, precipitation, and sediment concentration data. Estimates of annual water yield and annual sediment yield were generated by a modification of the computer program used to determine stream discharge. In a few instances, unusually high or questionable sediment concentration values, apparently caused by cattle present within the stream environs at the time of sampling or by sampling or analytical error, represented long sampling periods, i.e. 30 days. Where such conditions occurred, an estimated "corrected" level was substituted in order to generate a more approximate determination of the annual sediment yield. The relationships between measured values of suspended sediment vs stream discharge and specific conductance vs stream discharge were determined by linear regression and plotted using the computer programs.

STUDY AREA

Beaverhead County, Montana

Beaverhead County is located in the southwestern corner of Montana immediately southwest of Butte. Almost the entire county lies above 5,000 feet and is encircled on the north, west, and south by the Continental Divide. The area is characterized by broad grassland and sagebrush covered valley bottoms and river terraces, while the flanks of the numerous mountain ranges grade into forest lands. The westernmost headwaters of the Missouri River drain the county to the northeast via the Big Hole and Beaverhead rivers. The forested mountain areas are generally administered by the Beaverhead National Forest of the USDA, Forest Service; the lower mountain slopes and terrace lands are managed by the Department of Interior's Bureau of Land Management; while the valley bottoms are mainly in private holdings. The land resources of the county are primarily allocated to the raising of livestock, although lumbering, mining and recreation constitute secondary, but significant land uses.

The Bureau of Land Management's district office is located in the county seat of Dillon. The county contains a number of planning units administered by the Bureau. The Tendoy Planning Unit lies in the southwestern portion of the county and includes the Big Sheep Creek and Muddy Creek sample watersheds.

Big Sheep Creek Basin

The Big Sheep Creek sample watershed (Figure 1) includes approximately 182,700 acres and contains the Lower Big Sheep, Middle Big Sheep, Upper Big



Figure 1. Location of Big Sheep Creek Sample Basin, Tendency Planning Unit, Beaverhead County, Montana.

Big Sheep, Lower Muddy and Upper Muddy sampling stations. This predominantly east to southeast oriented watershed includes a large broad upper basin, as well as the distinctive Muddy Creek sample watershed described separately below. Local relief ranges from approximately 6,250 feet at the lower station to over 11,100 feet elevation in the high peaks along the Continental Divide to the southwest. The Upper Big Sheep Creek basin is a complex of sedimentary and metasedimentary materials, both calcareous and non-calcareous; metamorphics; Tertiary volcanics and pyroclastics; Tertiary sediments; and Quaternary glacial drift. The lower portion of the basin is confined within a relatively narrow valley, often flanked by steep limestone cliffs. The soils within the watershed include entisols, inceptisols, and mollisols, as well as extensive talus slopes and rock outcrops. The valley bottom lands and lower terraces and hills contain grassland and sagebrush communities, while the mountains are forested. Many of the higher mountains extend above the treeline. Approximately 60 percent of the basin is managed by the Beaverhead National Forest, 25 percent by the Bureau of Land Management, 15 percent is in private holdings, and less than 5 percent is State land. The valleys and lower slopes are used primarily for livestock grazing, while the major stream and uplands are prime recreational areas.

Lower Big Sheep Station

The Lower Big Sheep station No. 20 is located in the southwest portion of Section 30, Township 13S, Range 9W (Figure 2), approximately 100 yards upstream from the cattle guard. This location is found on the Dixon Mountain, Montana 7.5 Series U.S. Geological Survey Topographic Quadrangle. The station is depicted as site No. 20 on aerial photo No. 11-124-29 of this resource inventory report, and is shown on stream station

photos no. 20A and no. 20B. The station is located at 6,230 ft. elevation. The watershed above the station contains approximately 182,720 acres, has a local relief of 4,540 feet, and is oriented to the east-southeast.

Middle Big Sheep Station

The Middle Big Sheep station No. 19 is located in the southwest portion of Section 35, Township 13S, Range 10W (Figure 2), at the U.S.G.S. stream gauging station. This location is found on the Dixon Mountain, Montana 7.5 Series U.S. Geological Survey Topographic Quadrangle. The station is depicted as site No. 19 on aerial photo No. 11-124-31 of this resource inventory report, and is shown on stream station photo no. 19A. The station is located at 6,400 ft. elevation. The watershed above the station contains approximately 175,360 acres, has a local relief of 4,370 feet, and is oriented to the east-southeast.

Upper Big Sheep Station

The Upper Big Sheep station No. 16 is located at the east central portion of Section 10, Township 15S, Range 10W (Figure 2), approximately 200 yards downstream from the bridge. The original station was located on the downstream side of the bridge. This location is found on the Caboose Canyon, Montana 7.5 Series U.S. Geological Survey Topographic Quadrangle. The station is depicted as site No. 16 on aerial photo No. 14-126-102 of this resource inventory report, and is shown on stream station photos no. 16A and no. 16B. The station is located at 6,720 ft. elevation. The watershed above the station contains approximately 115,900 acres, has a local releif of 4,050 feet, and is oriented to the east.

The Upper Big Sheep precipitation station No. 16G is located in the central portion of Section 10, Township 15S, Range 10W (Figure 2). The gauge is approximately 500 yards upstream from the bridge on the north side of the creek across from Deadman Creek. The station is depicted as site No. 16G on aerial photo No. 14-126-102 of this resource inventory report.

Muddy Creek Basin

The Muddy Creek sample watershed (Figure 3) is a tributary basin of the Big Sheep Creek watershed. This southeast oriented basin contains approximately 39,400 acres and includes the Lower Muddy and Upper Muddy sampling stations. Moderate to steep mountain slopes descend to a series of lower hills and dissected terraces enclosing a relatively wide floodplain. Local relief in the basin ranges from approximately 6,450 feet to almost 9,600 feet elevation. The basin is composed of sedimentary materials including: limestones; Tertiary volcanics and pyroclastics, and Tertiary and Quaternary sediments. Entisols and inceptisols dominate the mountain slopes, while mollisols characterize the sage-grassland lower slopes, terraces, and valleys. The floodplain soils are primarily heavy smectite clay soils derived from Tertiary pyroclastics and give the Muddy Creek basin its character and name. Approximately 45 percent of the watershed is administered by the Beaverhead National Forest, 45 percent by the Bureau of Land Management, and nearly 5 percent each is State and private land. The predominant use in the basin is livestock grazing.

Lower Muddy Station

The Lower Muddy station No. 18 is located in the northeast portion of Section 10, Township 14S, Range 10W (Figure 4), approximately 15 yards

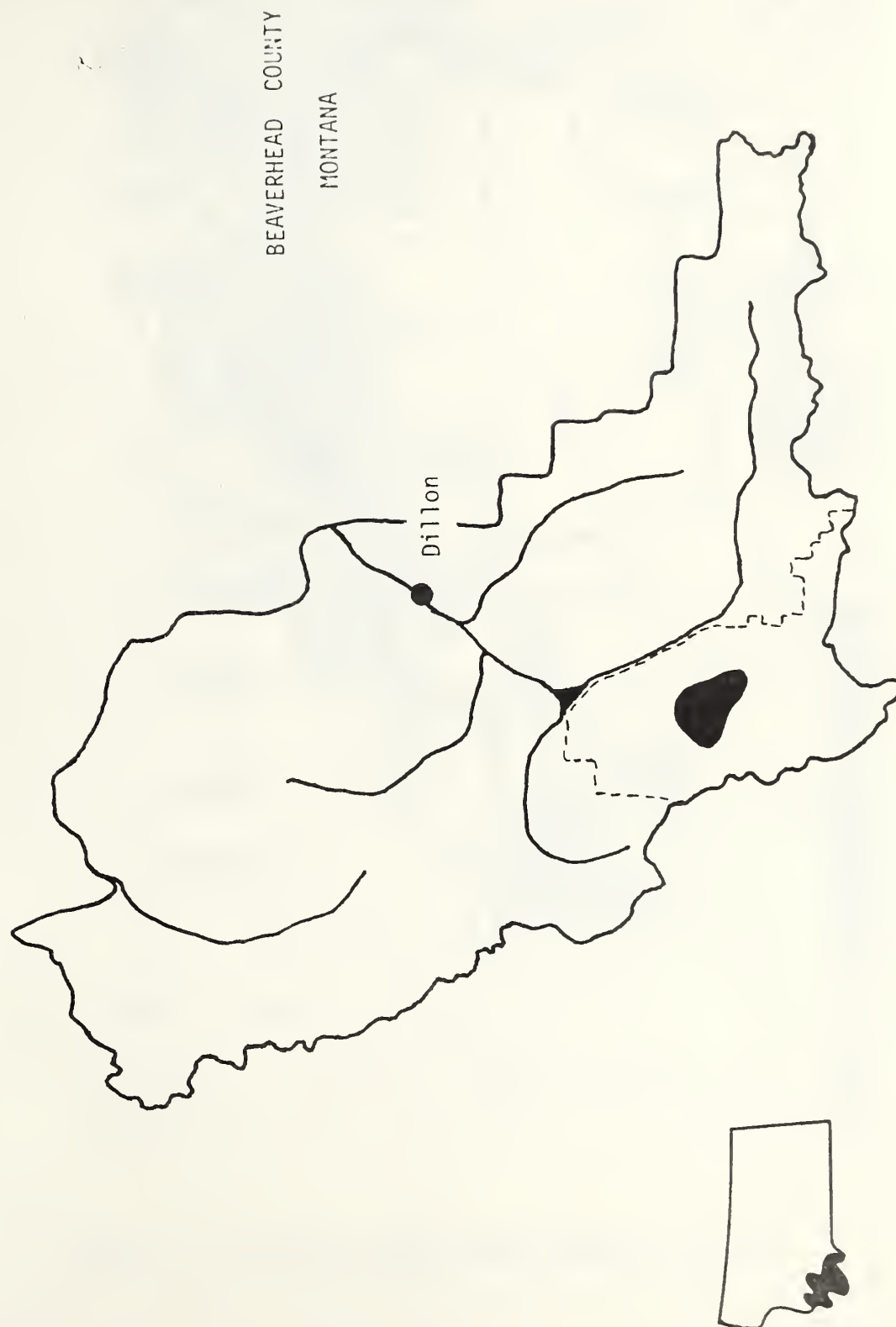


Figure 3. Location of Muddy Creek Sample Basin, Tendoy Planning Unit, Beaverhead County, Montana.

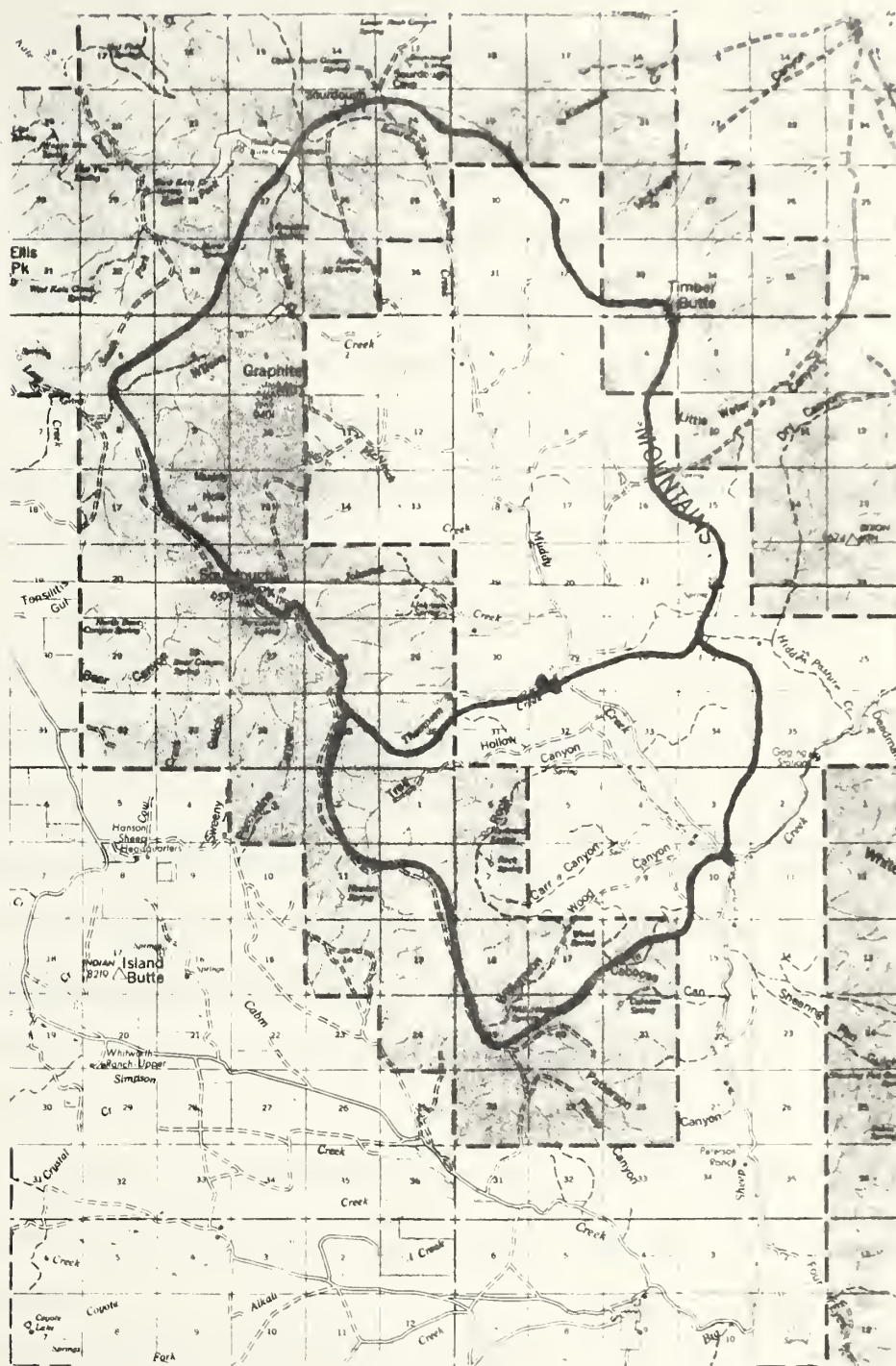


Figure 4. Location of Muddy Creek Sampling Stations.

upstream from where the creek crosses under the Big Sheep Creek road. The original station was located immediately on the upstream side of the road. This location is found on the Dixon Mountain, Montana 7.5 Series U.S. Geological Survey Topographic Quadrangle. The station is depicted as site No. 18 on aerial photo No. 11-125-83 of this resource inventory report, and is shown on stream station photos no. 18A and no. 18B. The station is located at 6,440 ft. elevation. The watershed above the station contains approximately 39,360 acres, has a local relief of 3,150 feet, and is oriented to the south-southeast.

Upper Muddy Station

The Upper Muddy Creek station No. 17 is located in the west central portion of Section 33, Township 13S, Range 10W (Figure 4), approximately 5 yards below fence line which crosses both the creek and road. This location is found on the Dixon Mountain, Montana 7.5 Series U.S. Geological Survey Topographic Quadrangle. The station is depicted as site No. 17 on aerial photo No. 11-124-31 of this resource inventory report, and is shown on stream station photos no. 7A and no. 7B. The station is located at 6,610 ft. elevation. The watershed above the station contains approximately 28,350 acres, has a local relief of 3,000 feet, and is oriented to the south-southeast.

The Upper Muddy precipitation station No. 17G (Figure 4) is located in the east central portion of Section 33, Township 13S, Range 10W approximately 50 yards due west of station on the north side of the fence. The station is depicted as site No. 17G on aerial photo No. 11-124-31 of this resource inventory report.

RESULTS AND DISCUSSION

The results of the water quality survey of the Big Sheep and Muddy sample basins of the Tendoy Planning Unit are summarized and briefly discussed below. The basic data for each station is found in the Appendix of this volume.

Big Sheep Creek Basin

The Big Sheep Creek sample basin was visited a total of 17 and 20 times during the two hydrologic years. There were no specific accessibility problems but residual channel ice and high flows made sampling difficult on several occasions at the Upper Big Sheep sampling station. This station was visited 15 and 19 times respectively.

Channel Stability Ratings

Big Sheep Creek was evaluated independently by Bureau personnel, their channel stability ratings are not included.

Precipitation

Precipitation was measured at the Upper Big Sheep precipitation station from April 21 through October 15, 1977 and from April 4 through September 11, 1978. The general precipitation patterns during these two fiscal years are compared to those of the Dillon and Lima weather stations (Figure 5). Apparently 1977 was the wetter of the two field seasons owing to the increased precipitation during both May and July.

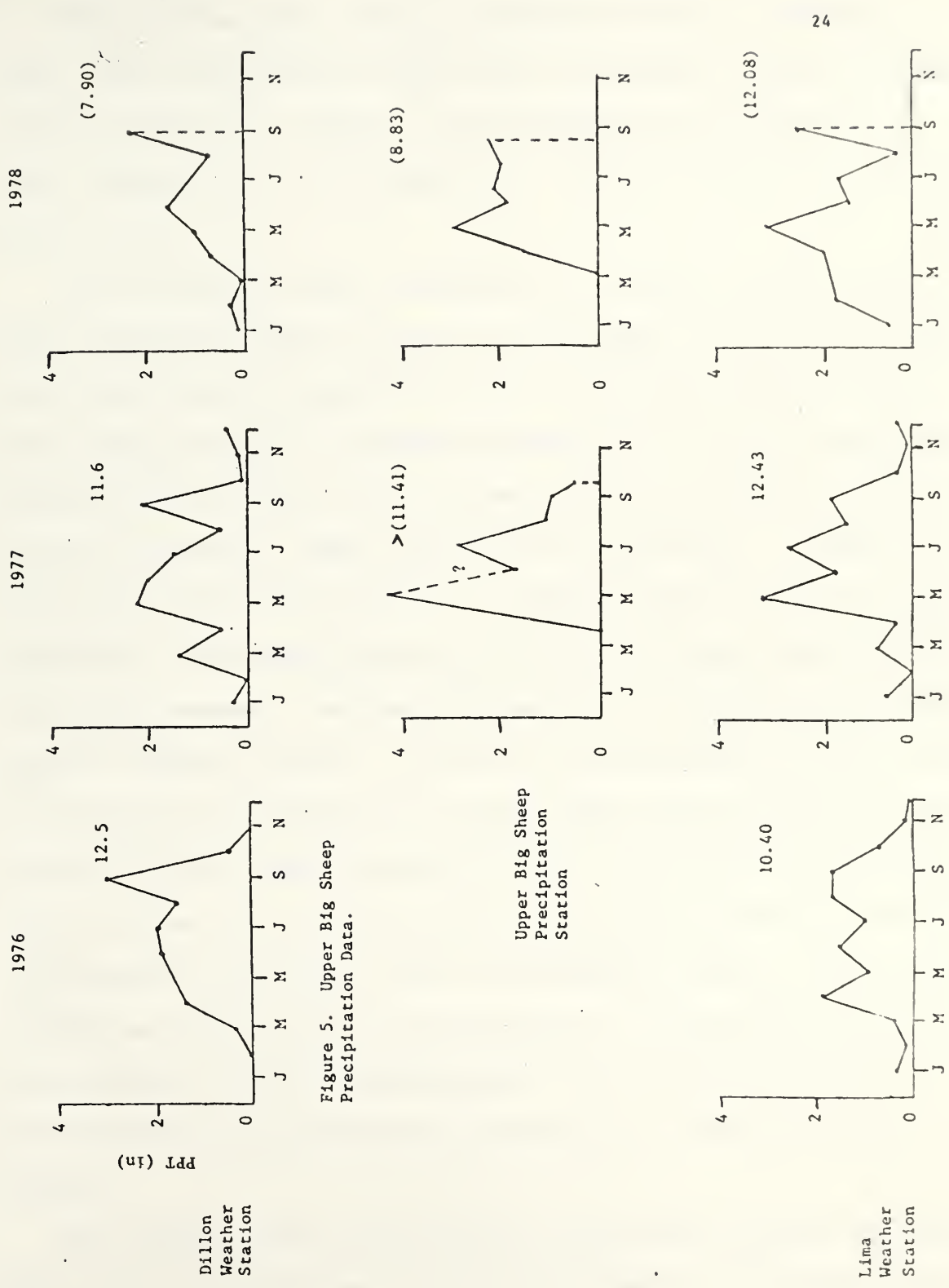


Figure 5. Upper Big Sheep Precipitation Data.

Stream Discharge

The Middle Big Sheep station was monitored by the U.S. Geological Survey. The staff-discharge rating curve for the Upper Big Sheep sampling station is presented in Figure 6. The gauging site was moved from the bridge downstream to a more accessible and ice free location after the first sampling year.

The 1977 and 1978 annual hydrographs for the Lower and Middle Big Sheep stations are combined (Figures 7 and 8) owing to the fact that they were compiled from data supplied by the U.S. Geological Survey for their stream gauging station at the Middle Big Sheep site. An early peak of 139 cfs occurred in mid-April, 1977, followed by the seasonal peak of 234 cfs in early to mid-June. Lowest flow was 40 cfs in mid-July. In 1978, an early peak of 130 cfs was followed by a moderate seasonal peak of 151 cfs in mid-June. The seasonal low flow of 34 cfs for the year occurred during the previous November. The Upper Big Sheep station exhibited quite similar patterns (Figures 9 and 10). An initial, but delayed peak of 97 cfs occurred in late April to be followed by the season peak in June estimated to be in excess of 122 cfs. Lowest recorded flow was 7 cfs in late September. An early peak flow of 67 cfs was monitored during the end of March, 1978, and was followed by the seasonal flood of approximately 182 cfs in mid-June. Seasonal low flow was 21 cfs in mid-late April. The differences noted in flow patterns for the two hydrologic years are primarily attributed to differences in annual precipitation patterns and to seasonal snow melt patterns.

The respective annual hydrograph data were used to estimate the annual water yields for the Big Sheep Creek stations (Table 1). The data indicate

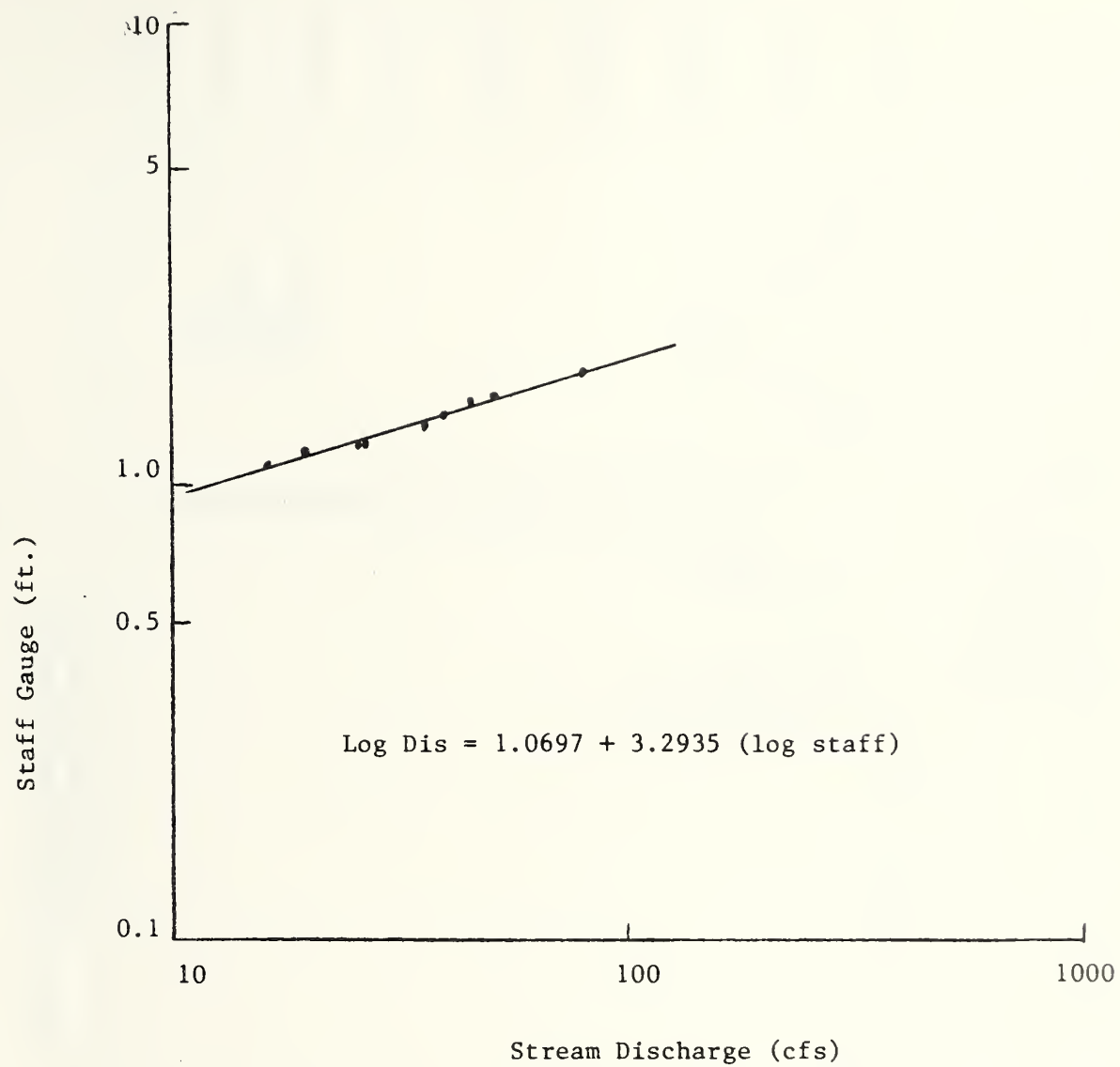


Figure 6. Staff-discharge Rating Curve for Upper Big Sheep Sampling Station.

FIGURE 7. ANNUAL HYDROGRAPH AND SEDIMENT LOADINGS
LOWER-MIDDLE BIG SHEEP - 1977

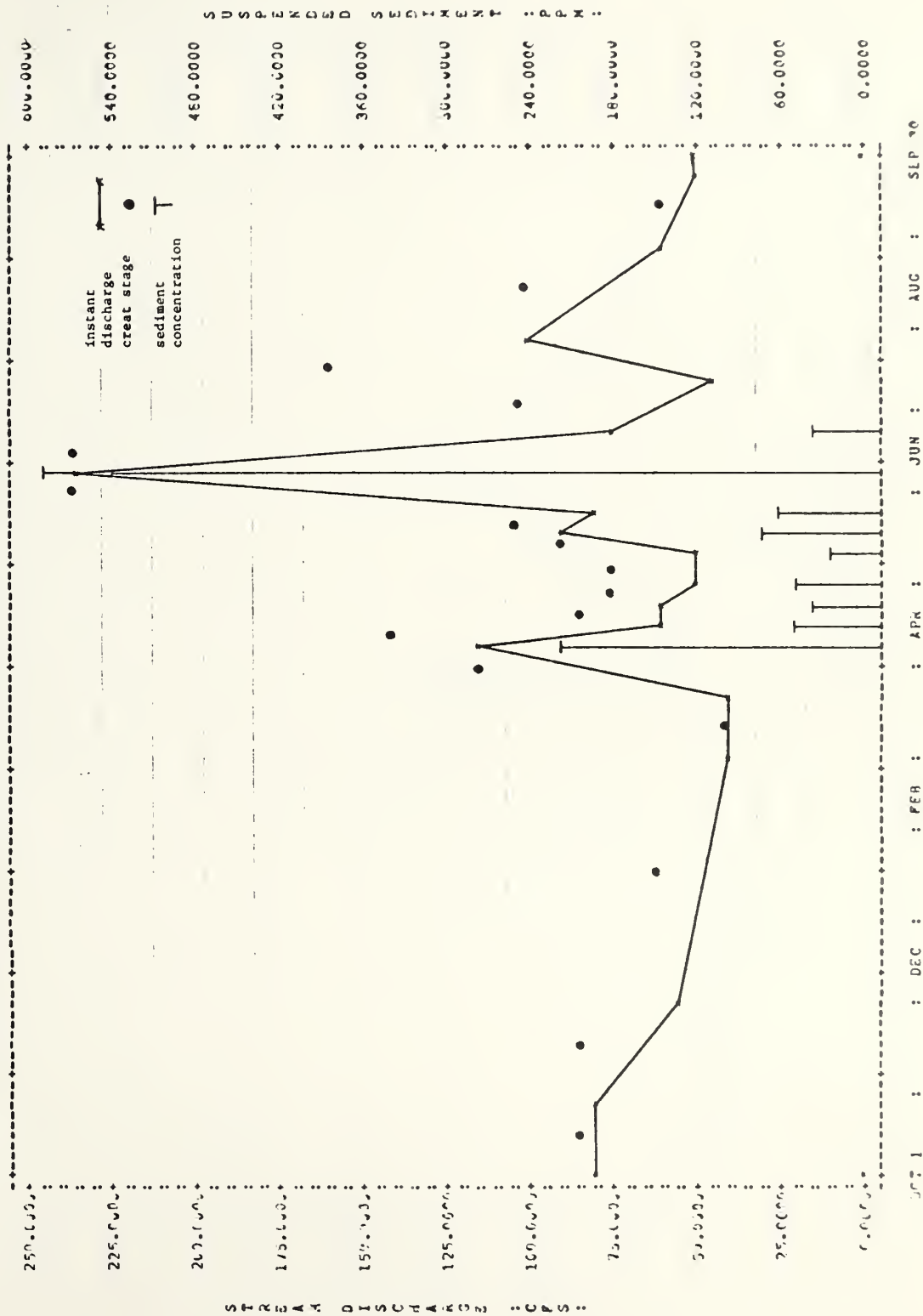


FIGURE 8. ANNUAL HYDROGRAPH AND SEDIMENT LOADINGS
LOWER-MIDDLE BIG SHEEP - 1978

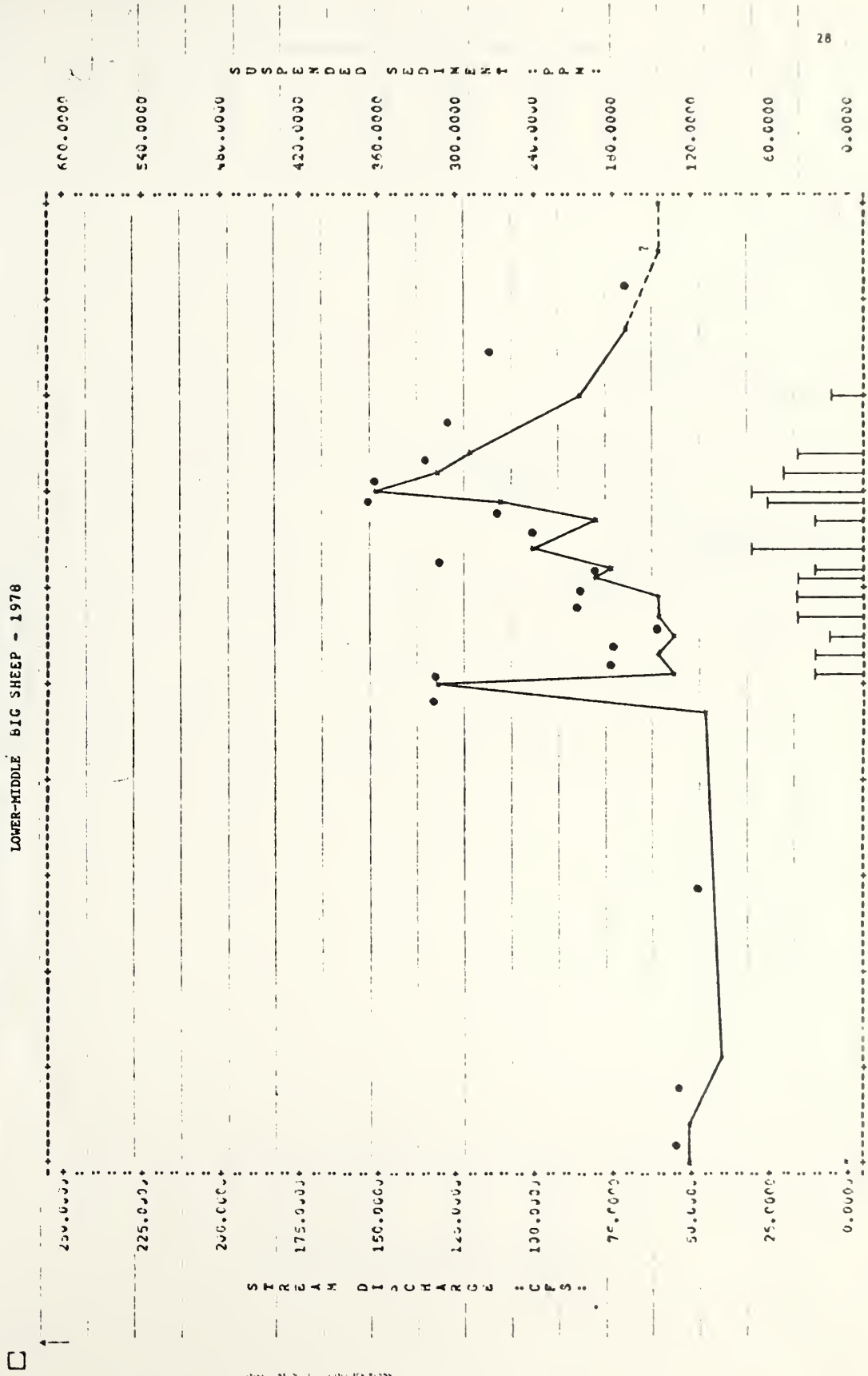


FIGURE 9. ANNUAL HYDROGRAPH AND SEDIMENT LOADINGS
UPPER BIG SHEEP - 1977

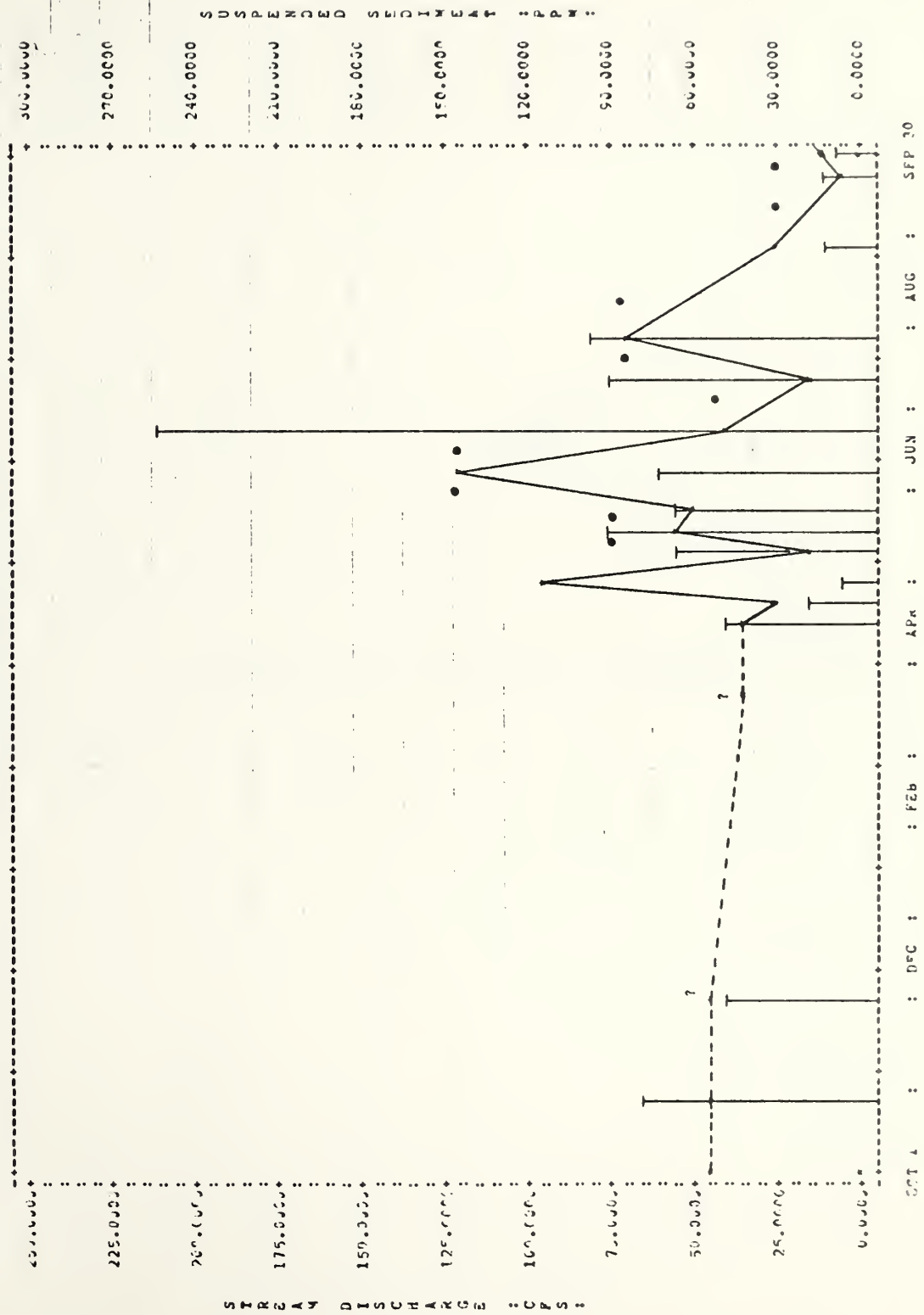
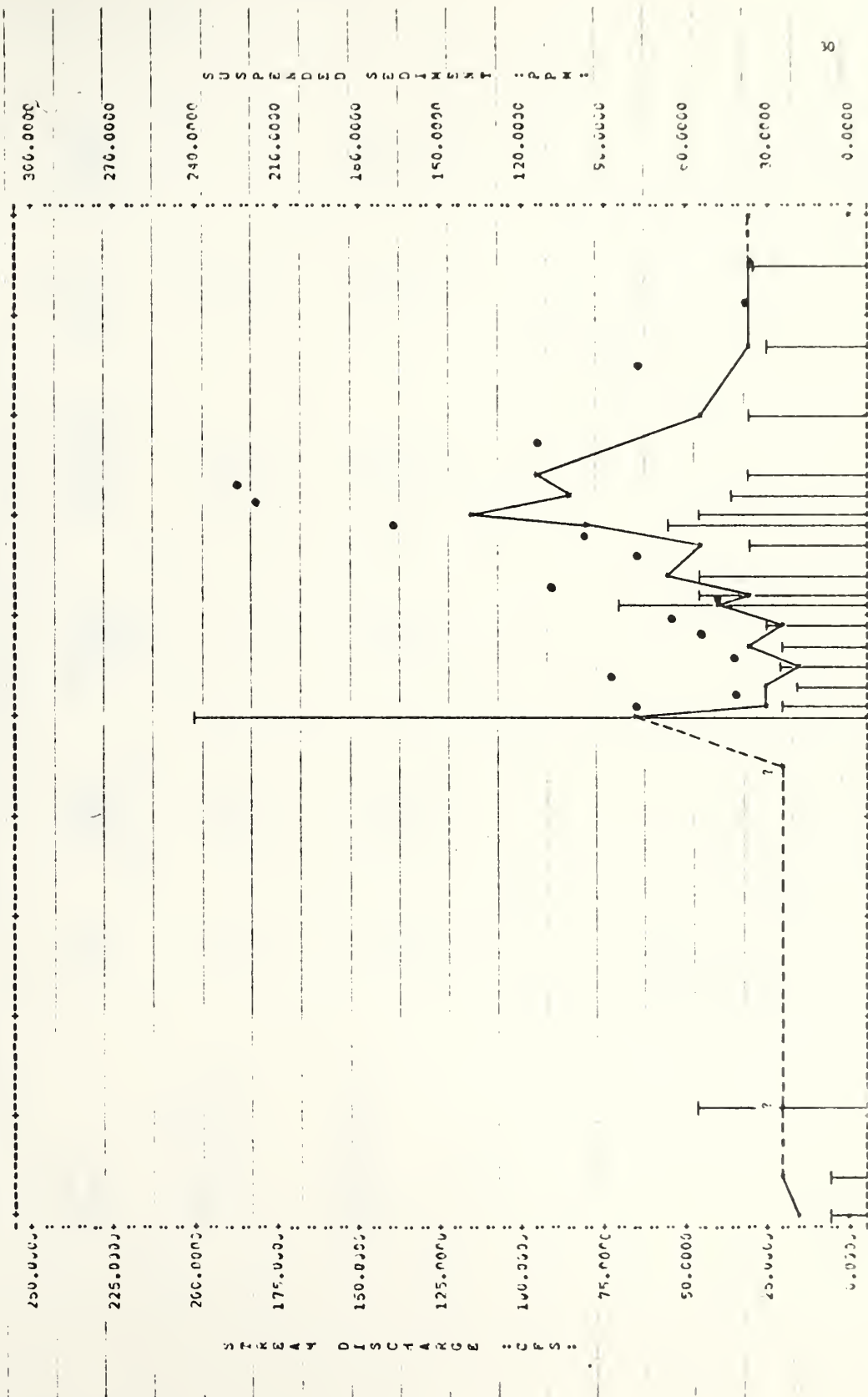


FIGURE 10. ANNUAL HYDROGRAPH AND SEDIMENT LOADINGS

UPPER BIG SHEEP - 1978



OCT 1 : DEC : JAN : FEB : MAR : APR : MAY : JUN : JUL : AUG : SEP 30

Table 1. Estimated Water and Sediment Yields for Big Sheep Creek Basin, 1977 - 1978.

Station Name	Water Year	Estimated Water Yield (ac. - ft.)	Estimated Sediment Yield (tons)	Contributing Watershed (acres)	Runoff (in. / ac.)	Sediment Yield (lbs/acre)
Lower - Middle Big Sheep Station	1977	50,200	--	179,000	3.37	--
	1978	46,300	--	179,000	3.10	--
Upper Big Sheep Station	1977	31,500	2,590	115,900	3.26	44.8
	1978	24,700	1,430	115,900	2.56	24.7

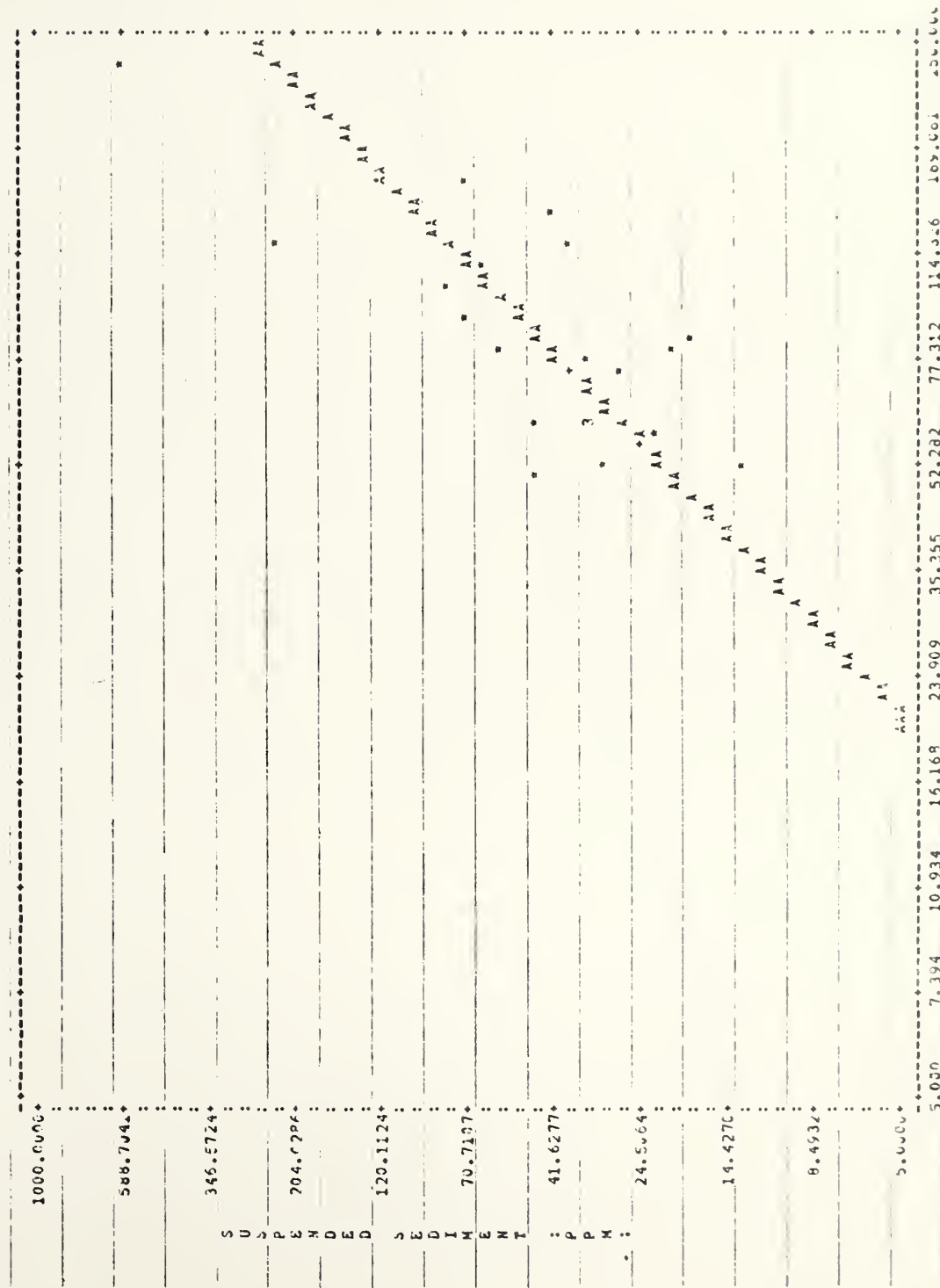
water yields of approximately 50,200 acre feet and 46,300 acre feet for the lower stations and 31,500 acre feet and 24,700 acre feet for the Upper station. The estimates for the lower stations compare favorably with those generated by the U.S. Geological Survey, i.e. 43,480 acre and 46,000 acre feet. Differences between the two sets of data are attributed to differences in the sampling schedules.

Suspended Sediment

The annual patterns of sediment concentrations for each station by hydrologic year are depicted in Figures 7-10. Suspended sediment samples for the lower stations were collected by U.S. Geological Survey personnel at the Deadman Gulch bridge approximately 1 1/2 miles downstream from the Middle Big Sheep sampling station. Suspended sediment concentrations at the lower stations ranged from 13 ppm at low flow to 589 ppm at high flow, while those for the Upper station ranged from 9 ppm to 242 ppm. The relationships between suspended sediment and stream discharge for each station were statistically significant, and are presented in Figures 11 and 12. The variability in sediment concentration with stream flow is partially attributed to a seasonal effect, specific storm effects, and to the hysteresis effect, whereby peak concentrations of suspended sediment generally occur prior to peak runoff during the rising stage (Gregory and Walling, 1973, pp. 215-219). Annual sediment yields were estimated only for the Upper Big Sheep station from respective water yield and sediment concentration data (Table 1). The Upper Big Sheep basin produced approximately 2,590 tons and 1,430 tons of suspended sediment respectively during the two sample years. The difference between the two years is largely attributed to differences in flow regime.

FIGURE 11. SUSPENDED SEDIMENT VS STREAM DISCHARGE --- LOWER-MIDDLE BIG SHEEP

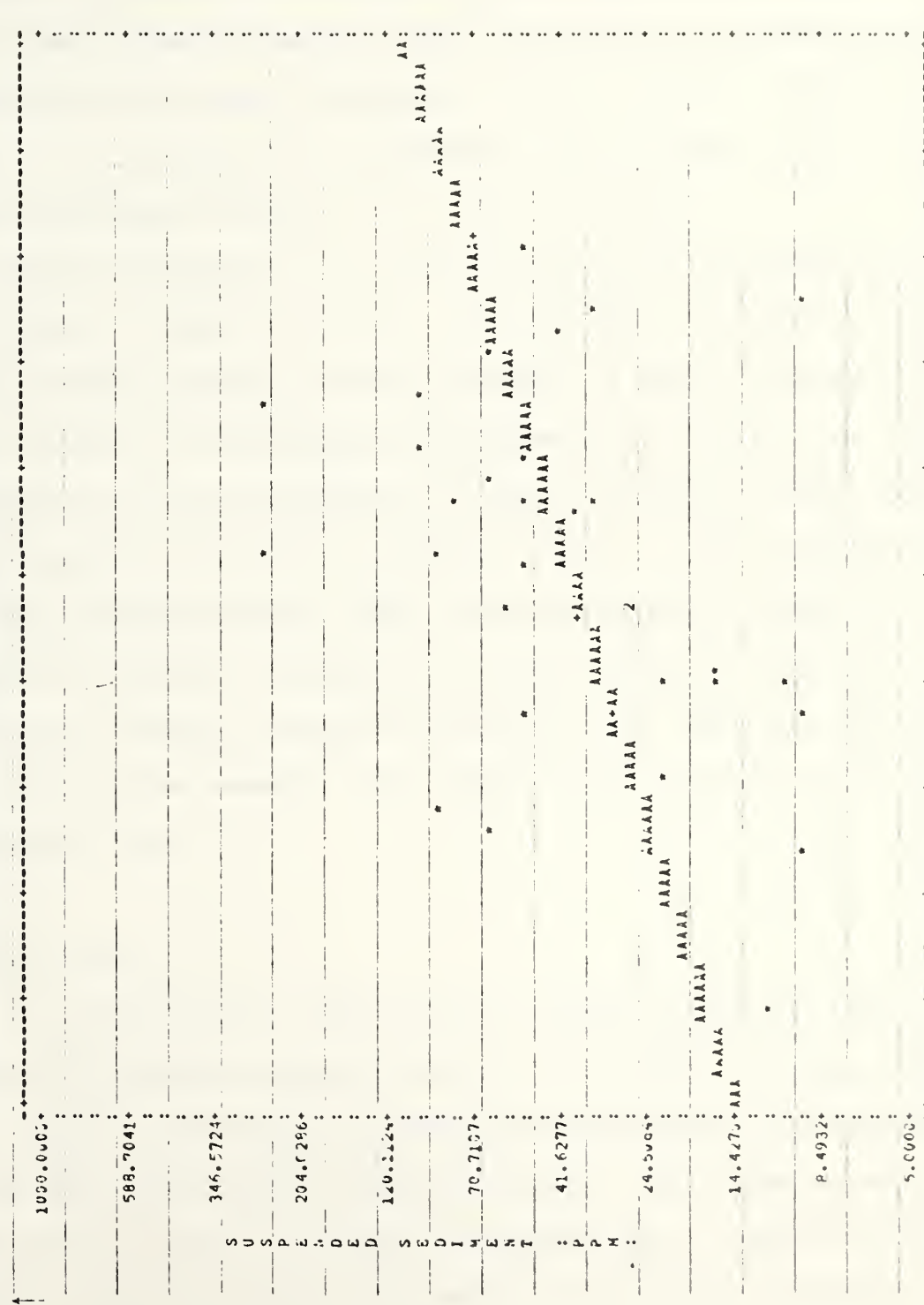
LUG SED = 1.5904(LUG DIS) - 1.4041



STREAM DISCHARGE :CFS:

FIGURE 12. SUSPENDED SEDIMENT VS STREAM DISCHARGE - UPPER BIG SHEEP

LOG SED = 0.8026 + 0.5102(LOG DIS)



STREAM DISCHARGE (CFD)

Hydrochemical Parameters

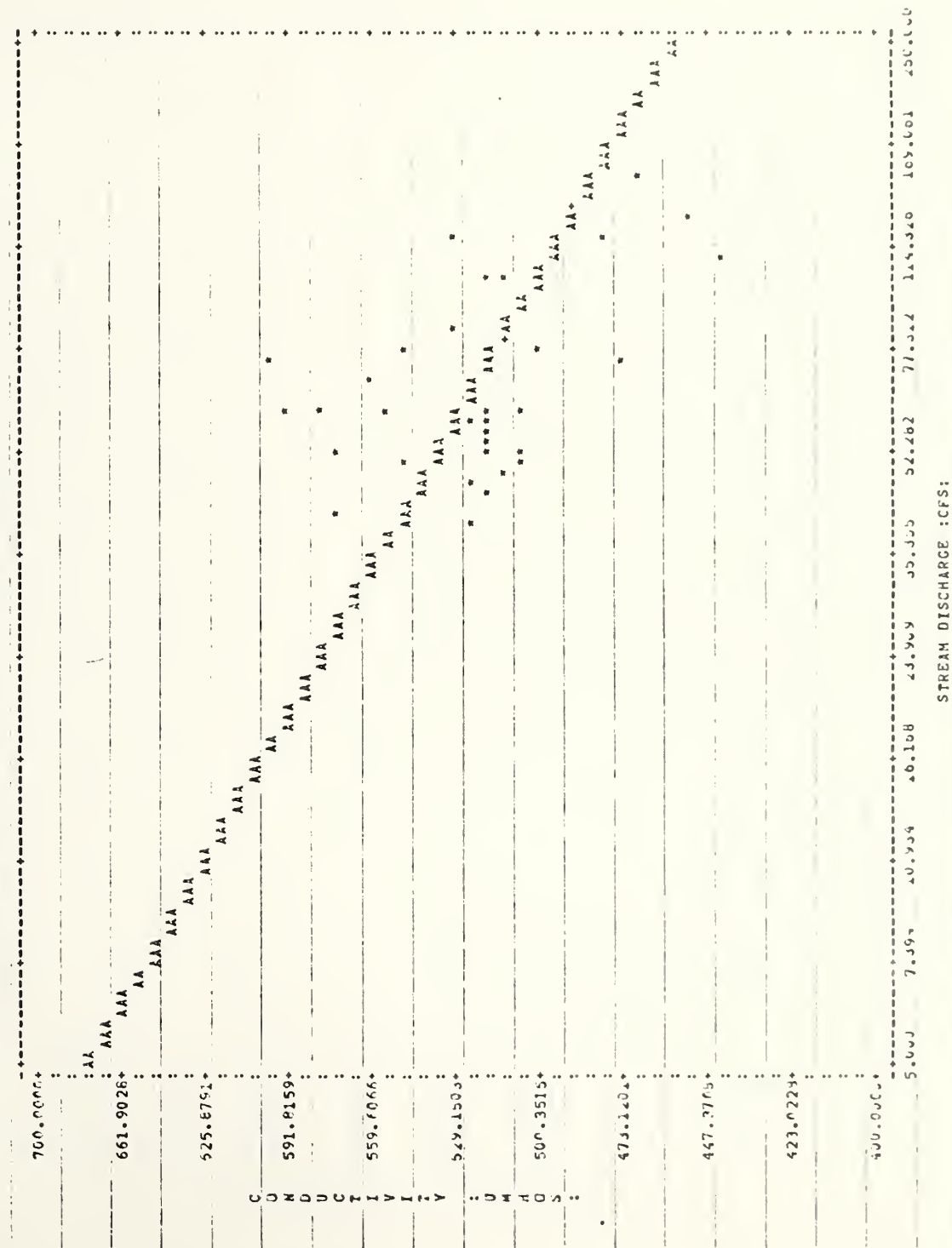
The concentration of dissolved solids is inversely related to stream discharge so that lower concentrations occur during periods of high runoff, while higher concentrations are found during periods of low summer base flow (Gunnerson, 1967; Gregory and Walling, 1973, pp. 219-225). Patterns for specific ions, especially the ecologically important ones, often vary from this generalization (Likens, et al., 1977, pp. 74-76).

Specific conductance for the Lower Big Sheep station ranged from a low of 440 μ mhos to a high of 675 μ mhos, from 430 μ mhos to 680 μ mhos for the Middle Big Sheep station, and from 390 μ mhos to a high of 760 μ mhos for the Upper station. The relationships between specific conductance and stream discharge for the Lower and Middle Big Sheep stations were statistically significant and are presented in Figures 13 and 14. This relationship for the Upper Big Sheep station, however, was not significant (Figure 15). Variation in specific conductance with stream discharge is partially attributed to seasonal and storm hysteresis effects (Gregory and Walling, pp. 219-225). The ranges in ionic concentrations for specific ions are presented in Table 2.

Bacteria Levels

The concentration of fecal and total coliform in streams draining rangeland watersheds is directly related to the number of cattle present, their access to the stream, the physical and hydrological characteristics of the basin, local weather conditions (Kunkle, 1970; Stephensen and Street, 1978), and the time of day (Kunkle and Meiman, 1968). Seasonal patterns include a spring "flushing" effect during the rising stage (Kunkle and Meiman, 1968), with high counts during the low flow summer period, counts which often continue for some period after the cattle have been removed from

LOC COND = 2.502 - 0.058(LOC DIS) (SID 207) 0569.9 - 705.2



STREAM DISCHARGE :CFS:

FIGURE 14. CONDUCTIVITY VS STREAM DISCHARGE - MIDDLE BIG SHEEP

LOG COND = 2.8974 - 0.1000(LOG DIS)

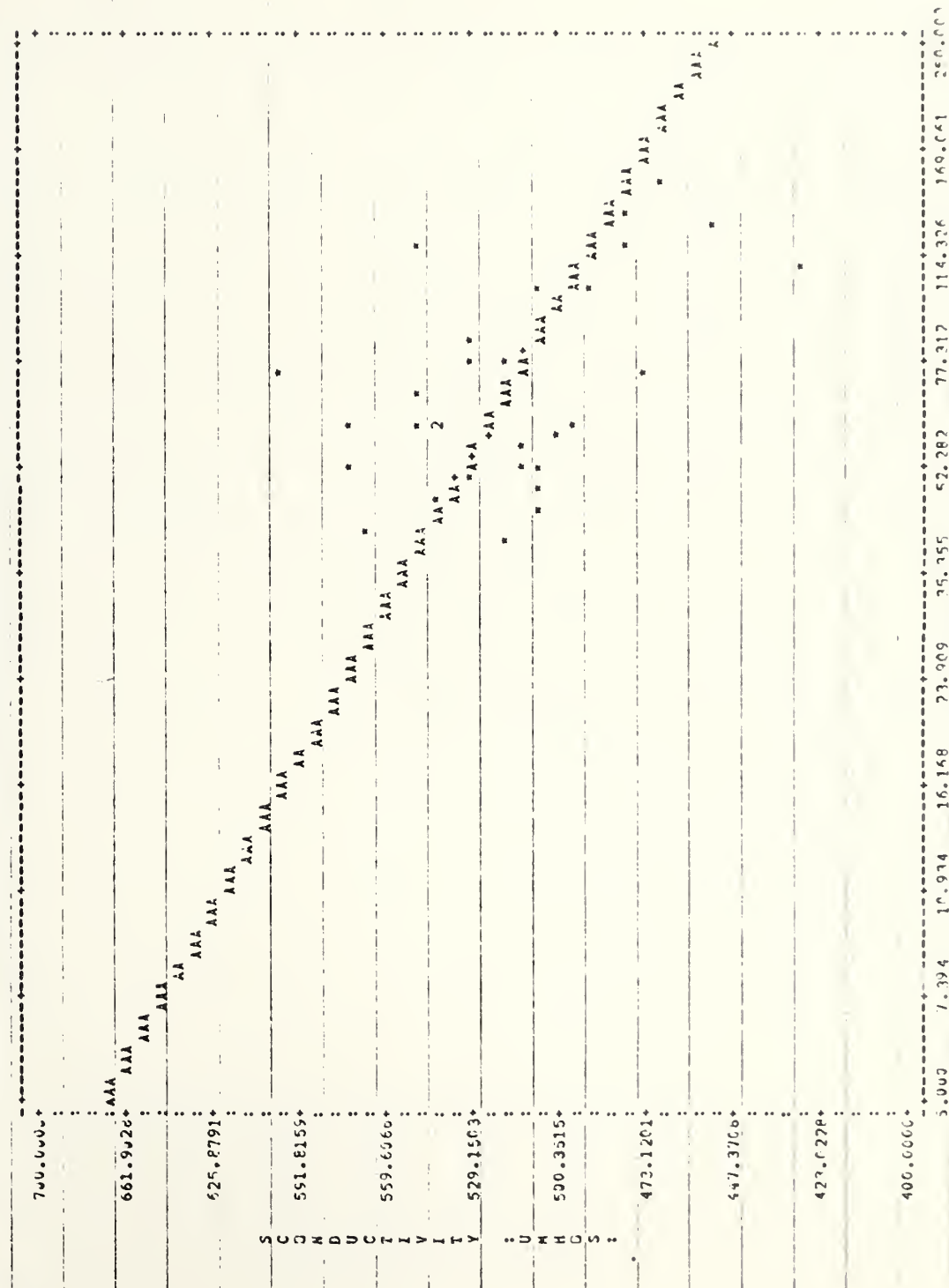
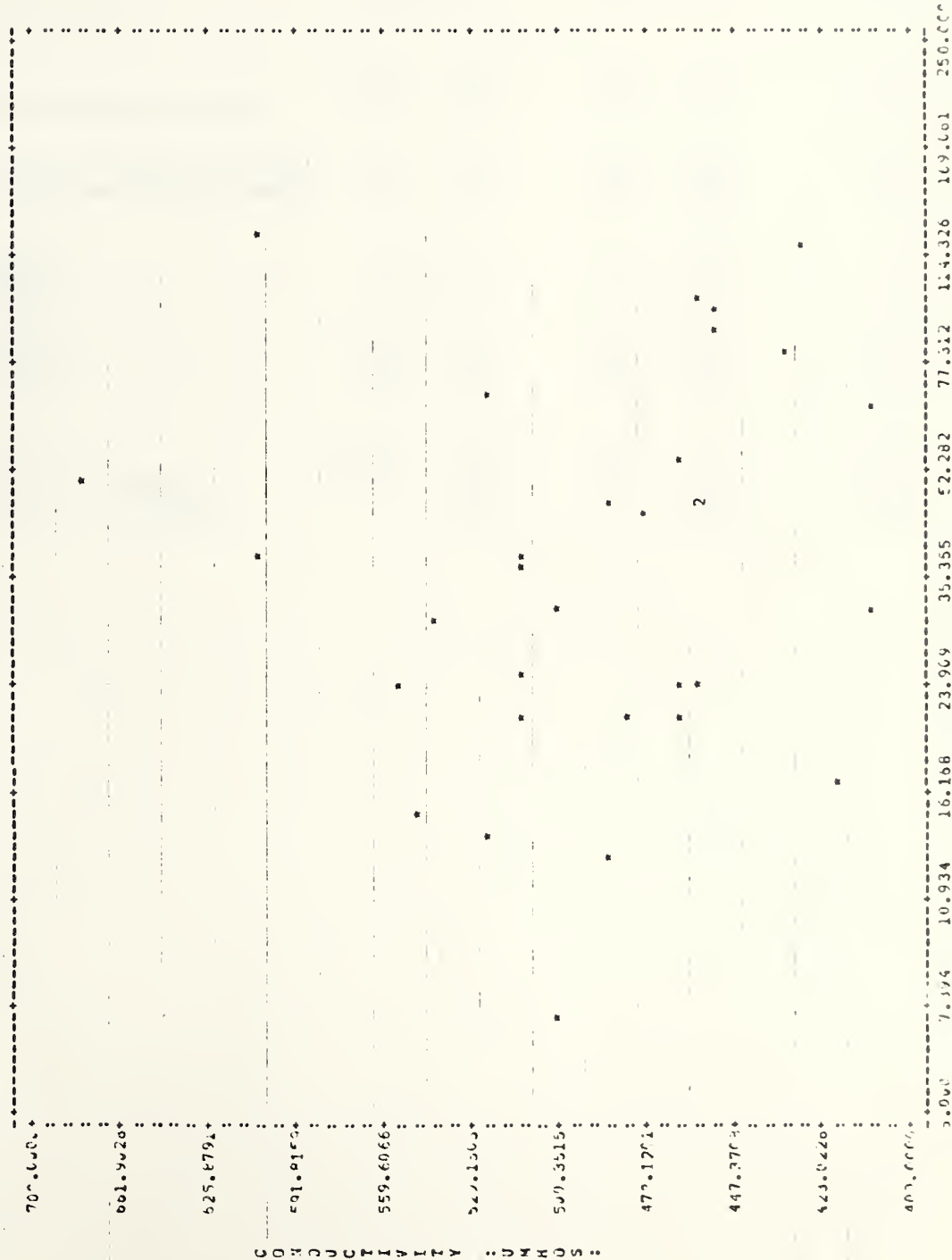


FIGURE 15. CONDUCTIVITY VS STREAM DISCHARGE - UPPER BIG SHEEP



STREAM DISCHARGE :CFS:

Table 2. Ranges in Hydrochemical Parameters for Big Sheep Creek, 1977 - 1978.

	Lower Big Sheep Station	Middle Big Sheep Station	Upper Big Sheep Station
pH	8.05 - 8.40	7.89 - 8.39	7.91 - 8.43
Alkalinity (CaCO_3) (mg/l)	152 - 209	151 - 217	163 - 276
Specific Conductance (umhos)	440 - 675	430 - 680	390 - (760)
Total Dissolved Solids (mg/l)	286 - 439	280 - 442	254 - (494)
Ca (mg/l)	61 - 104	53 - 105	43 - 95
Mg (mg/l)	19 - 35	15 - 35	12 - 25
Na (mg/l)	14 - 29	14 - 26	21 - 51
K (mg/l)	1.4 - 3.4	1.3 - 4.0	0.97 - 5.3
HCO_3 (mg/l)	185 - 254	184 - 265	181 - 337
SO_4 (mg/l)	62 - 231	91 - 204	28 - (143)
NH_4 (mg/l)	< .01 - (.30)	< .01 - .10	< .01 - .08
$\text{NO}_2 + \text{NO}_3 - \text{N}$ (mg/l)	< .01 - .09	< .01 - .12	< .01 - .11
PO_4 (Ortho) - P (mg/l)	T - .034	T - .020	.002 - .081

the area (Stephensen and Street, 1978). This seasonal pattern may briefly be modified by local storms which produce their own "flushing" effect, and which may or may not be followed by a short term dilution period.

The concentrations of fecal coliform for the Big Sheep Creek sampling stations for the study period are presented in Table 3. Higher values occurred during the grazing season, but the patterns were not consistent. Maximum fecal coliform levels were 140, 628, and 245 colonies/100 mls respectively for each station. None of the sample coliform counts exceeded the 200 colony/100 ml limit of the Montana Water Quality Criteria for the Lower Big Sheep station, while 8 percent of the Middle station, and 17 percent of the Upper station counts were in excess. Low values were associated with the spring season.

Comments

The Big Sheep Creek basin is a geologically complex unit. The limestone components contribute warm spring waters that are high in calcium, magnesium, and carbonate. Evidence indicates that Muddy Creek also contributes high sulfate concentrations to the stream. Increases in discharge alone are not well correlated to a decrease in total solute concentrations, indicating that other factors are operative. There is insufficient evidence of livestock concentrations and movements within the basin to specifically demonstrate their influence on fecal coliform levels. Because of the limited number of samples taken and the nature of the hydrochemical characteristics sampled, relationships between the water quality characteristics of Big Sheep Creek and the Montana Water Quality Criteria cannot be addressed.

Table 3. Fecal Coliform Counts (colonies/100 mls) for Big Sheep Creek,
1977 - 1978.

	Lower Big Sheep Station		Middle Big Sheep Station		Upper Big Sheep Station	
	1977 - 1978		1977 - 1978		1977 - 1978	
April	---		---		---	
May	72	1	2	1	2	1
June	16(?)	26	18(?)	43	10(?)	101(?)
July	140(?)	20	628(?)	57	2(?)	243*
August	5(?)	30	3*	13	5(?)	10(?)
September	20(?)	37	12(?)	78	28(?)	245(?)
October	3(?)		3(?)		6(?)	
November	< 2(?)		< 2(?)		4(?)	

* Stock visually present

(?) Stock presence uncertain

Muddy Creek Basin

The Lower Muddy Creek sample basin was visited a total of 17 and 20 times during the two hydrologic years. There were no specific accessibility problems; however, residual channel ice made sampling difficult during early 1977. The Upper Muddy station was monitored 15 and 19 times respectively.

Channel Stability Ratings

Muddy Creek was evaluated on August 16, 1976. The lower portion of Muddy Creek between its mouth to below the confluence of Muddy and McNinch creeks was rated as 'poor' (125) (Table 4), while the upper portion extending the Beaverhead National Forest boundary was rated as 'fair' (103) (Table 5).

Precipitation

Precipitation was measured at the Upper Muddy precipitation station from April 21 through November 10, 1977 and from April 4 through September 15, 1978. The general precipitation patterns during these two fiscal years are compared to those of the Dillon and Lima weather stations (Figure 16). Apparently 1977 was the wetter year for the Upper Muddy station owing to the heavy precipitation peaks during May and July.

Stream Discharge

The staff-discharge rating curves for the Lower Muddy and Upper Muddy sampling stations are presented in Figures 17 and 18. The Upper Muddy station remained nearly stable during the two sampling years. The Lower Muddy station was moved after 1977 because of residual ice conditions and its unstable channel cross section.

Table 4

R-1 STREAM CHANNEL STABILITY FIELD EVALUATION FORM

Lower Muddy
August 16, 1976

Item Rated	Stability Indicators by Classes			POOR
	EXCELLENT	GOOD	FAIR	
I. UPPER BANKS				
Landform Slope	Bank slope gradient <30%	(2) Bank slope gradient 30-40%	(4) Bank slope gradient 40-60%	(5) Bank slope gradient 60%+
Mass Wasting (Existing or Potential)	No evidence of past or potential for future mass wasting into channel.	(3) Mostly healed over. Low future potential.	(6) With some raw spots eroded by water during high flows.	(8) Imminent danger of same.
Debris Jam Potential (Floatable Objects)	Essentially absent from immediate channel area.	(2) Present but mostly small twigs and limbs.	(5) Present, volume and size are both increasing.	(6) Moderate to heavy amounts, predominantly larger sizes.
Bank Protection from	90%+ plant density. Vigor and variety suggests a deep, dense root mass.	(3) Species or lower vigor suggests a less dense or deep root mass.	(6) 50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	(9) Species & less vigor indicate poor, discontinuous, and shallow root mass.
Vegetation				
II. LOWER BANKS				
Channel Capacity	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	(1) Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8-15.	(2) Barely contains present peaks. Occasional overbank floods. W/D ratio 15-25.	(3) Inadequate. Overbank flows common. W/D ratio >25.
Bank Rock Content	65%+ with large, angular boulders 12" + numerous.	(2) 40 to 65%, mostly small boulders to cobble 6-12".	(4) 20 to 40%, with most in the 3-6" diameter class.	(6) <20% rock fragments of gravel sizes, 1-3" or less.
Obstructions Flow Deflectors Sediment Traps	Rocks, old logs firmly embedded. Flow pattern of pool & riffles stable without cutting or deposition.	(2) Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	(4) Moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling of pools.	(6) Frequent obstructions and deflectors cause bank erosion yearlong. Sed. traps full, channel migration occurring.
Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.	(4) Outcrops & constrictions. Raw banks may be up to 12".	(8) Significant. Cuts 12"-24" high. Rock mat overhangs and sloughing evident.	(12) Almost continuous cuts, some over 24" high. Failure of overhangs frequent.
Deposition	Little or no enlargement of channel or point bars.	(4) Formation, most from coarse gravels.	(8) Gravel & coarse sand on old and some new bars.	(12) Extensive deposits of predominantly fine particles. Accelerated bar development.
III. BOTTOM				
Rock Angularity	Sharp edges and corners. Plane surfaces roughened.	(1) Rounded corners & edges, surfaces smooth & flat.	(2) Corners & edges well rounded in two dimensions.	(4) Well rounded in all dimensions, surfaces smooth.
Brightness	Surfaces dull, darkened, or stained. Gen. not "bright".	(1) Mostly dull but may have up to 35% bright surfaces.	(2) Mixture, 50-50% dull and bright, ± 15%, to 35-65%.	(4) Predominately bright, 65%+, exposed or scoured surfaces.
Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping. No change in sizes evident.	(2) Moderately packed with some overlapping.	(4) Mostly a loose assortment with no apparent overlap.	(6) No packing evident. Loose assortment, easily moved.
Bottom Size Distribution	Stable materials 80-100%.	(4) Distribution shift slight. Stable materials 50-80%.	(8) Moderate change in sizes. Stable materials 20-50%.	(12) Marked distribution change. Stable materials 2-20%.
Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.	(6) 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	(12) 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	(18) More than 50% of the bottom in a state of flux or change nearly yearlong.
Clinging Aquatic Vegetation (Moss & Algae)	Abundant. Growth largely moss like, dark green, perennial. In swift water 100%.	(1) Common. Algal forms in low velocity & pool areas. Moss here too and after waters.	(2) Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	(4) Perennial types scarce or absent. Yellow-green, short term bloom may be present.
COLLECTOR TOTALS				

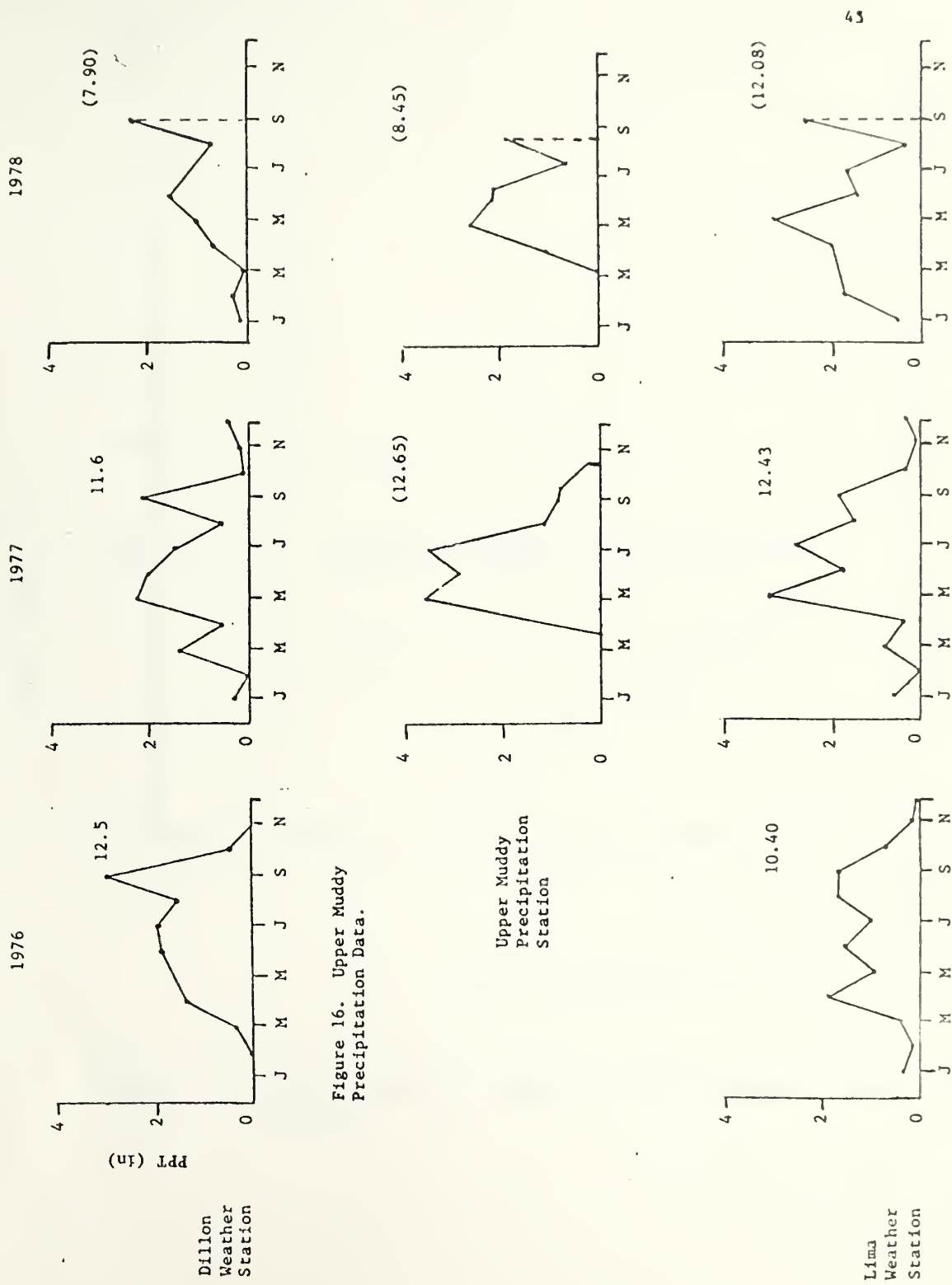
Add the values in each column for a total reach score here. (2- = + 0.5 + 1.22 + 1.91 = 12.5).

Reach score of: (<38=Excellent, 39-76=Good, 77-114=Fair, 115=Poor.

Table 5
R-1 STREAM CHANNEL STABILITY FIELD EVALUATION FORM

Item Rated	Stability Indicators by Classes			
	EXCELLENT	GOOD	FAIR	POOR
UPPER BANKS				
Bank Slope	(2) Bank slope gradient <30% No evidence of past or potential for future mass wasting into channels.	(2) Bank slope gradient 30-40% Infrequent and/or very small future potential.	(3) Bank slope gradient 40-60% Moderate frequency & size, with some raw spots eroded by water during high flows.	(6) Bank slope gradient 60% + Frequent or large, causing sediment nearly yearlong OR imminent danger of same.
Debris Jam Potential (Floatable Objects)	(2) Essentially absent from immediate channel area.	(2) Present but mostly small twigs and limbs.	(3) Present, volume and size are both increasing.	(6) Moderate to heavy amounts, predominantly larger sizes.
Bank Protection from Vegetation	(3) 90% + plant density. Vigor and variety suggests a deep, dense root mass.	(3) 70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	(6) 50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	(9) Species & less vigor indicate poor, discontinuous, and shallow root mass.
LOWER BANKS				
Channel Capacity	(1) Ample for present plus some increases. Peak flows contained. W/D ratio <7.	(1) Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8-15.	(2) (3) peaks. Occasional overbank floods. W/D ratio 15-25.	(3) Inadequate. Overbank flows common. W/D ratio >25.
Bank Rock Content	(2) 65% + with large, angular boulders 12" + numerous.	(2) 40 to 65%, mostly small boulders to cobble 6-12".	(4) 20 to 40%, with most in the 3-6" diameter class.	(6) <20% rock fragments of gravel sizes, 1-3" or less.
Obstructions	(2) Rocks, old logs firmly embedded. Flow pattern of pool & riffles stable without cutting or deposition.	(2) Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors never and less firm.	(6) Moderately frequent, moderately unstable obstructions & deflectors cause bank erosion yearlong. Sed. traps full, channel migration occurring.	(8) Frequent obstructions and deflectors cause bank erosion yearlong. Sed. traps full, channel migration occurring.
Cutting	(2) Little or none evident. Infrequent raw banks less than 6" high generally.	(4) Some, intermittently at outcrops & constrictions. Raw banks may be up to 12".	(8) Significant. Cuts 12"-24" high. Root mat overhangs and alouphing evident.	(12) Almost continuous cuts, some over 24" high. Failure of overhangs frequent.
Deposition	(2) Little or no enlargement of channel or point bars.	(4) Some new increases in bar formation, most from coarse gravels.	(8) Moderate deposition of new gravel & coarse sand on old and some new bars.	(12) Extensive deposits of predominately fine particles. Accelerated bar development.
ROCK ANGULARITY				
Sharp edges and corners, plane surfaces roughened.	(1) Sharp edges and corners, plane surfaces roughened.	(1) Rounded corners & edges, surfaces smooth & flat.	(2) Corners & edges well rounded in two dimensions.	(3) Well rounded in all dimensions, surfaces smooth.
Brightness	(1) Surfaces dull, darkened, or stained. Gen. not "bright".	(1) Mostly dull but may have up to 35% bright surfaces.	(2) Mixture, 50-50% dull and bright, ± 15%, ie 35-65%.	(3) Predominately bright, 65% +, exposed or scoured surfaces.
Consolidation or Particle Packing	(2) Assorted sizes tightly packed and/or overlapping.	(2) Moderately packed with some overlapping.	(4) Mostly a loose assortment with no apparent overlap.	(6) No packing evident. Loose assortment, easily moved.
Bottom Size Distribution	(4) No change in sizes evident. Stable materials 80-100%.	(4) Distribution shift slight. Stable materials 50-80%.	(8) Moderate change in sizes. Stable materials 20-50%.	(12) Marked distribution change. Stable materials 0-20%.
Present Stable Materials	(6) Less than 5% of the bottom affected by scouring and deposition.	(6) 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	(12) 30-50% affected. Deposits 6 scour at obstructions, constrictions, and bends, some filling of pools.	(18) More than 50% of the bottom in a state of flux or change nearly yearlong.
Scouring and Deposition	(1) Abundant. Growth largely moss like, dark green, perennial. In swift water too.	(1) Velocity & pool areas. Moss here too and water water.	(2) Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	(3) Perennial types scarce or absent. Yellow-green, short term bloom may be present.
Climbing Aquatic Vegetation (Moss & Algae)				
COLUMN TOTALS				
Add the values in each column for a total reach score here. (2. — + 6.19 + 7.59 + 7.25 = 103).				

Reach score of: <30=Excellent, 39-76=Good, 77-114=Fair, 115=Poor.



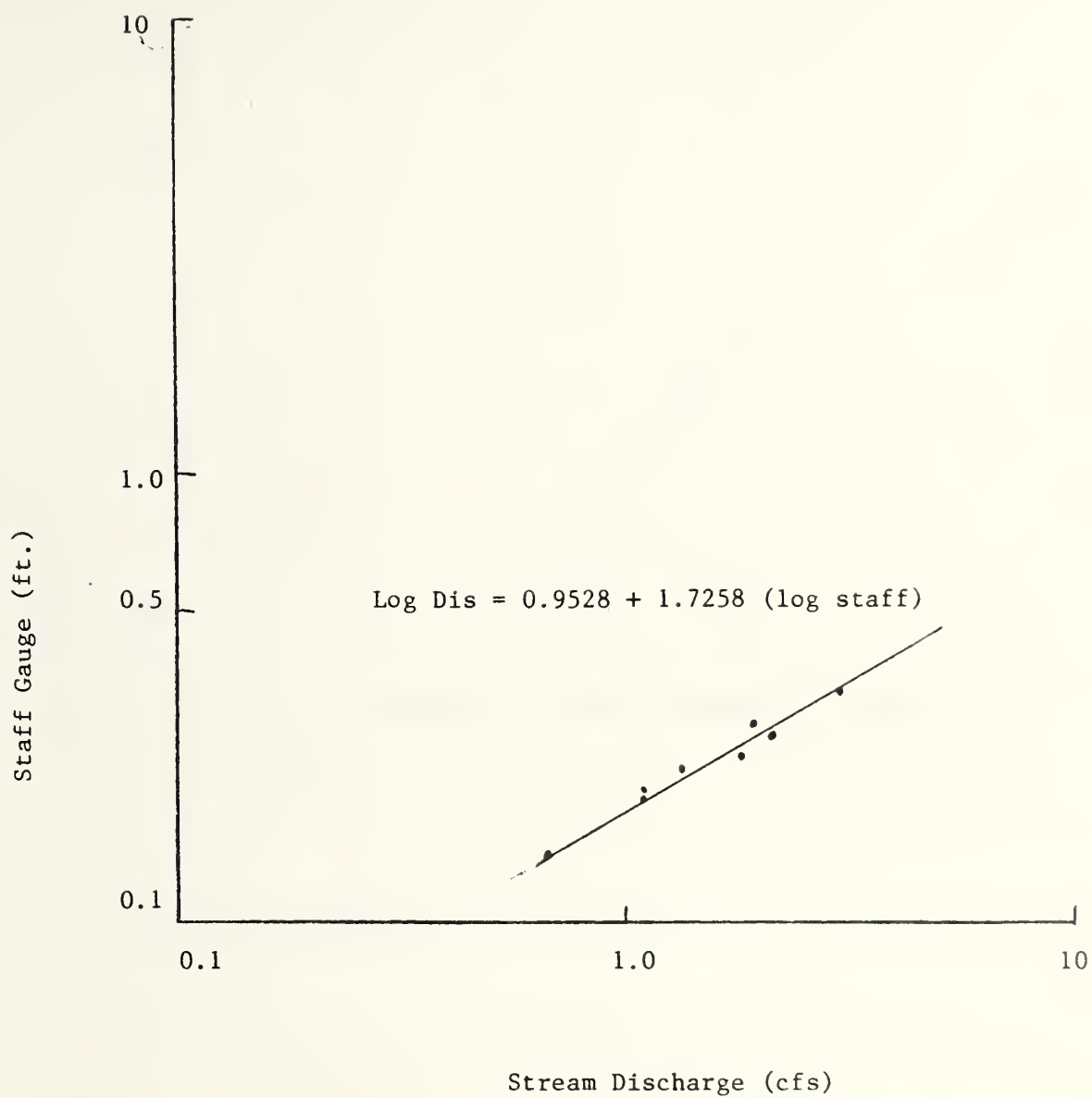


Figure 17. Staff-discharge rating Curve for Lower Muddy Sampling Station.

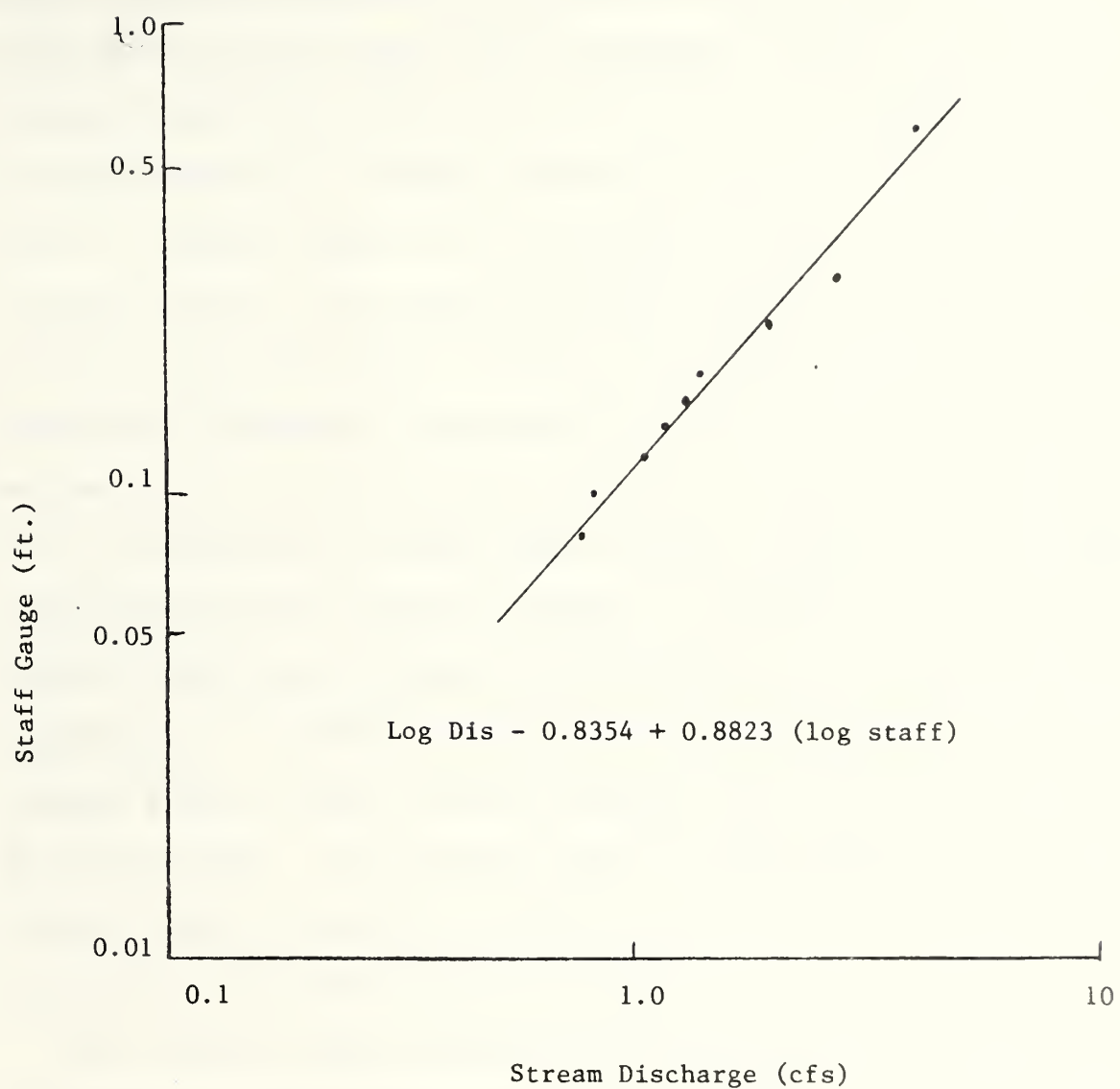


Figure 18. Staff-discharge Rating Curve for Upper Muddy Sampling Station.

The 1977 and 1978 annual hydrographs for the Lower Muddy and Upper Muddy Creek sampling stations are presented in Figures 19-22. Peak flow during 1977 at the Lower Muddy station apparently occurred in early April during an unusually warm period. This peak of 13 cfs was monitored above and below channel ice. A higher flow may also have occurred during this period. A secondary peak of 8.1 cfs was noted in early June. The lowest recorded flow was 1.3 cfs during the previous October. The 1978 year produced an early peak flow of 3.9 cfs in early April which preceeded the seasonal peak discharge of approximately 5.0 cfs in late May. The lowest recorded flow for 1978 was 1.0 cfs in mid-July. An estimated peak discharge of 5.1 cfs was noted at the Upper Muddy station in mid-April, 1977, although a higher flow may have occurred previously. A second peak of 5.3 cfs followed in late May. The lowest recorded flow for the year was 1.3 cfs in late September. In 1978, an annual peak flow of 3.3 cfs was estimated for late May, while the lowest flow was recorded at 0.90 cfs in the mid-April and late September. The differences noted in flow patterns for the two hydrologic years are largely attributed to differences in the annual precipitation and seasonal snow melt patterns.

The respective annual hydrograph data were used to estimate the annual water yields for each station (Table 6). During the wetter 1977 hydrologic year, the estimated yield for the Upper Muddy station was comparable to that of the Lower Muddy station. These values approximated 1,570 acre feet. During 1978, however, the Lower Muddy station was estimated to have yielded 1,260 acre feet, as opposed to only 940 acre feet for the Upper Muddy sampling station.

FIGURE 19. ANNUAL HYDROGRAPH AND SEDIMENT LOADINGS.
LOWER MUDDY - 1977

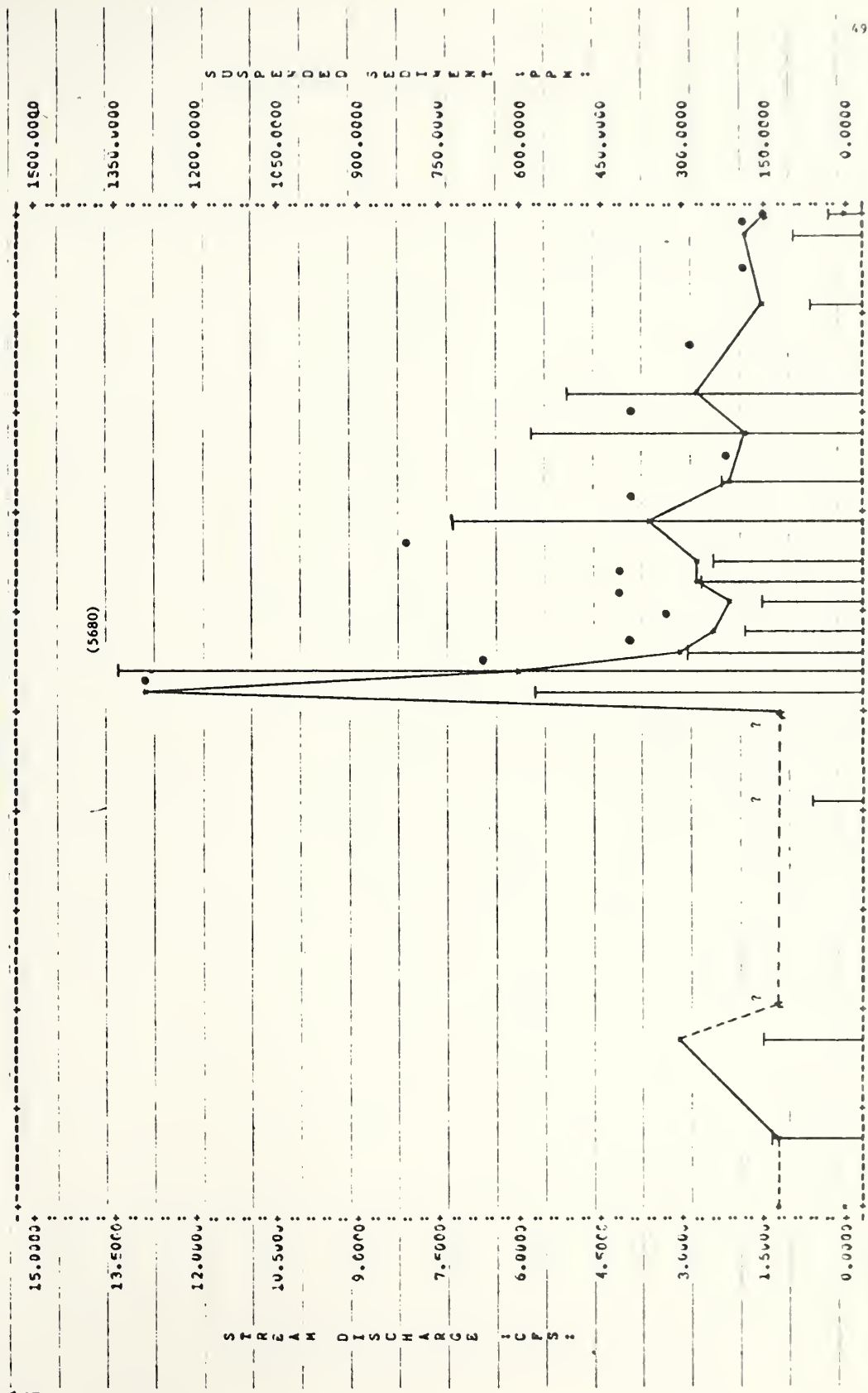


FIGURE 20. ANNUAL HYDROGRAPH AND SEDIMENT LOADINGS

LOWER MUDDY - 1978

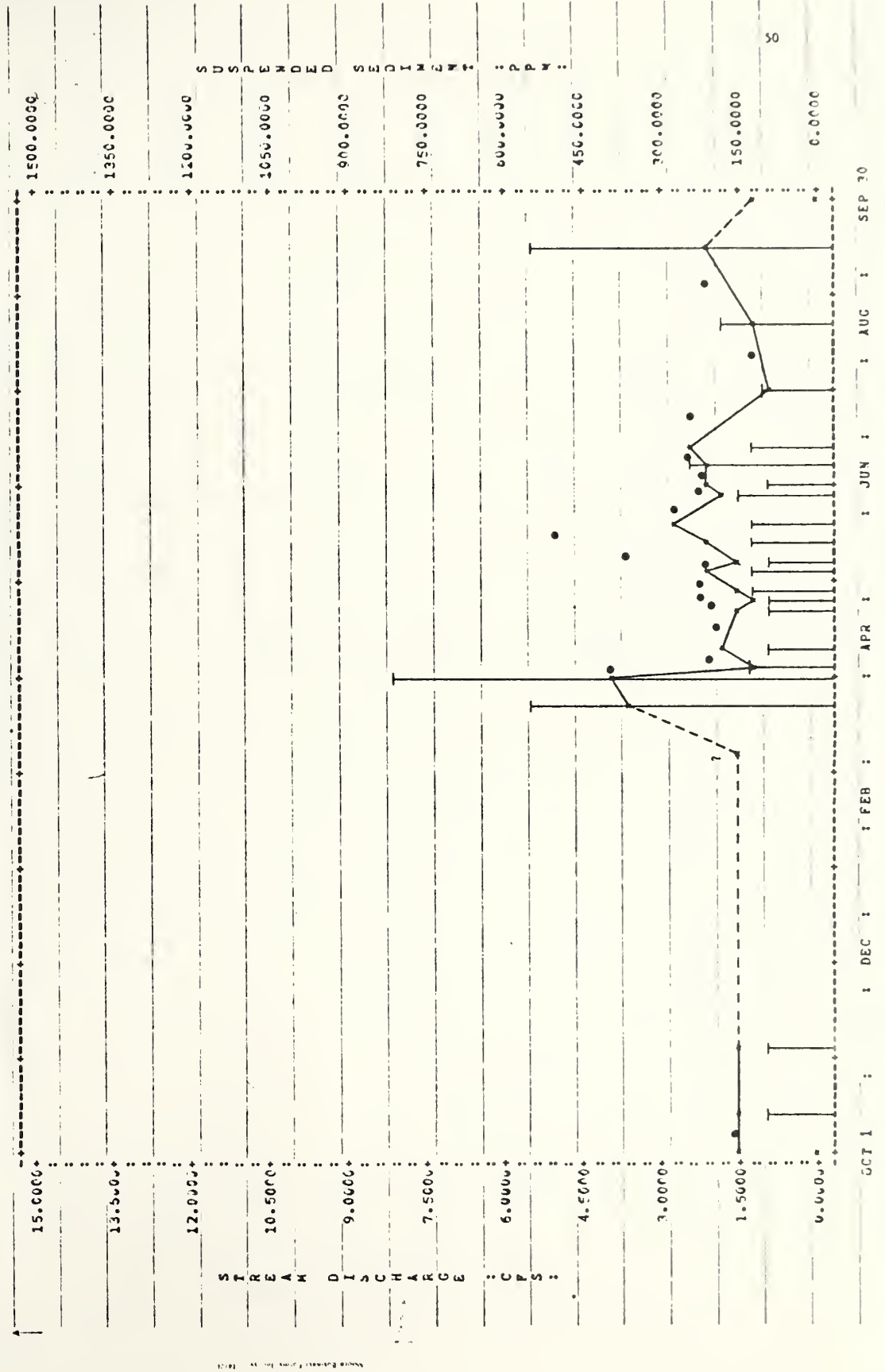


FIGURE 21. ANNUAL HYDROGRAPH AND SEDIMENT LOADINGS
UPPER MUDDY - 1977

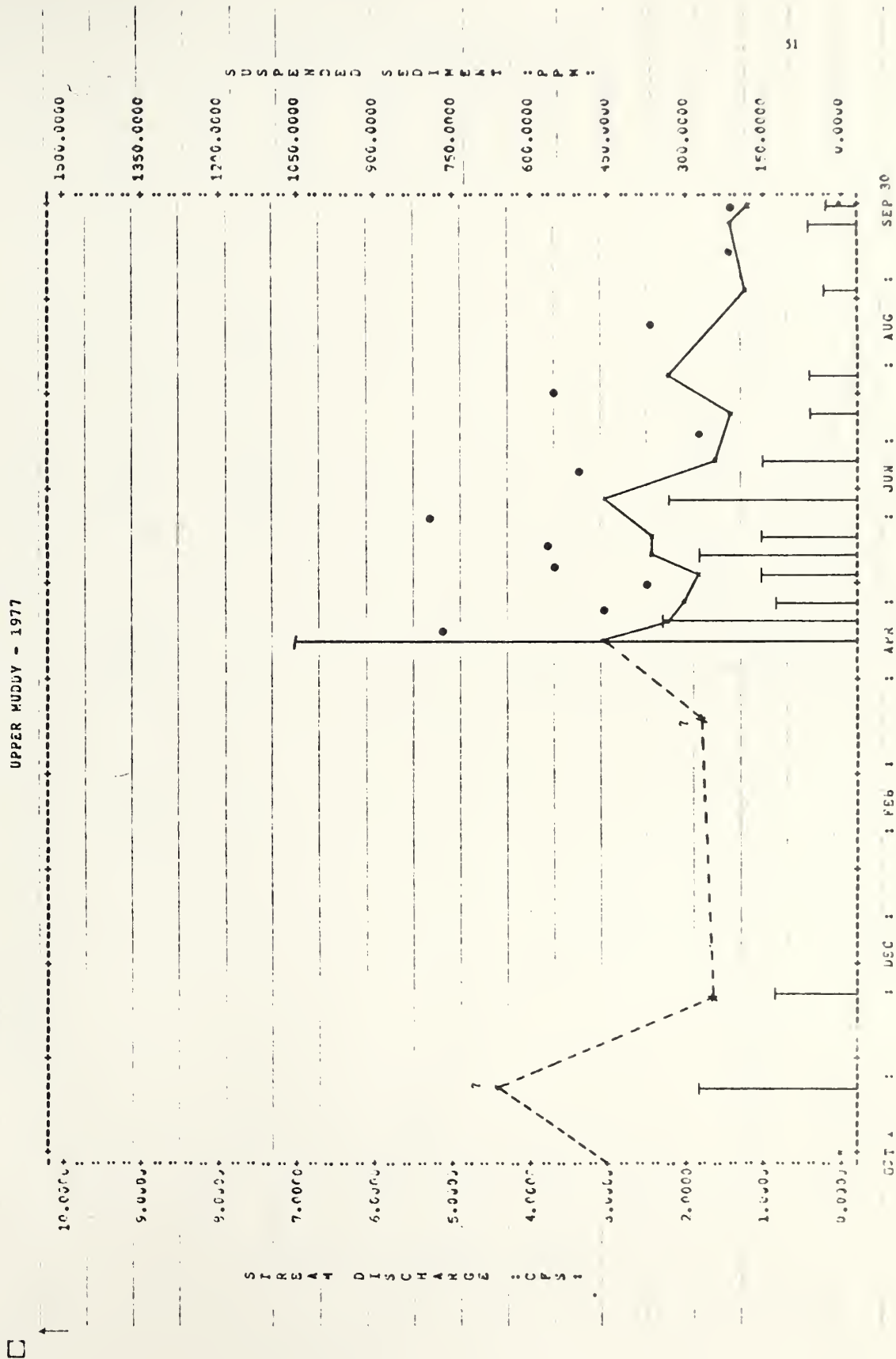


FIGURE 22. ANNUAL HYDROGRAPH AND SEDIMENT LOADINGS
UPPER MUDDY - 1978



Table 6. Estimated Water and Sediment Yields for Muddy Creek Sample Basin, 1977 - 1978.

Station Name	Water Year	Estimated Water Yield (ac. - ft.)	Estimated Sediment Yield (tons)	Contributing Watershed (acres)	Runoff (in. / ac.)	Sediment Yield (lbs/acre)
Lower Muddy Creek Station	1977	1,560	1,150	39,360	0.48	58.4
	1978	1,260	370	39,360	0.38	18.8
Upper Muddy Creek Station	1977	1,570	460	28,350	0.66	32.7
	1978	940	163	28,350	0.40	11.5

These differences are primarily attributed to differences in the fall and winter flow regimes at the Upper station for the two sample years and to the timing of the sampling visits.

Suspended Sediment

The annual patterns of sediment concentrations for each station by hydrologic year are depicted in Figures 19-22. Suspended sediment concentrations at the Lower Muddy station ranged from 44 ppm at low flow to 5,680 ppm at high flow, while those for the Upper Muddy station ranged from 37 ppm to 1,060 ppm. The relationships between suspended sediment and stream discharge for each station were statistically significant, and are presented in Figures 23 and 24. The variability in sediment concentration with stream flow is partially attributed to a seasonal effect, specific storm effects, and to the hysteresis effect, whereby peak concentrations of suspended sediment generally occur prior to peak runoff during the rising stage (Gregory and Walling, 1973, pp. 215-219). Annual sediment yields for the two sample stations were estimated from respective water yield and sediment concentration data (Table 6). The Lower and Upper Muddy stations produced approximately 1,150 tons and 460 tons of suspended sediment respectively during 1977. These yields decreased to 370 tons and 163 tons for the less active 1978 hydrologic year.

Hydrochemical Parameters

The concentration of dissolved solids is inversely related to stream discharge so that lower concentrations occur during periods of high runoff, while higher concentrations are found during periods of low summer base flow

FIGURE 23. SUSPENDED SEDIMENT VS. STREAM DISCHARGE - LOWER MUDDY

LOG SED = 1.7997 + 1.4066(LOG DIS)

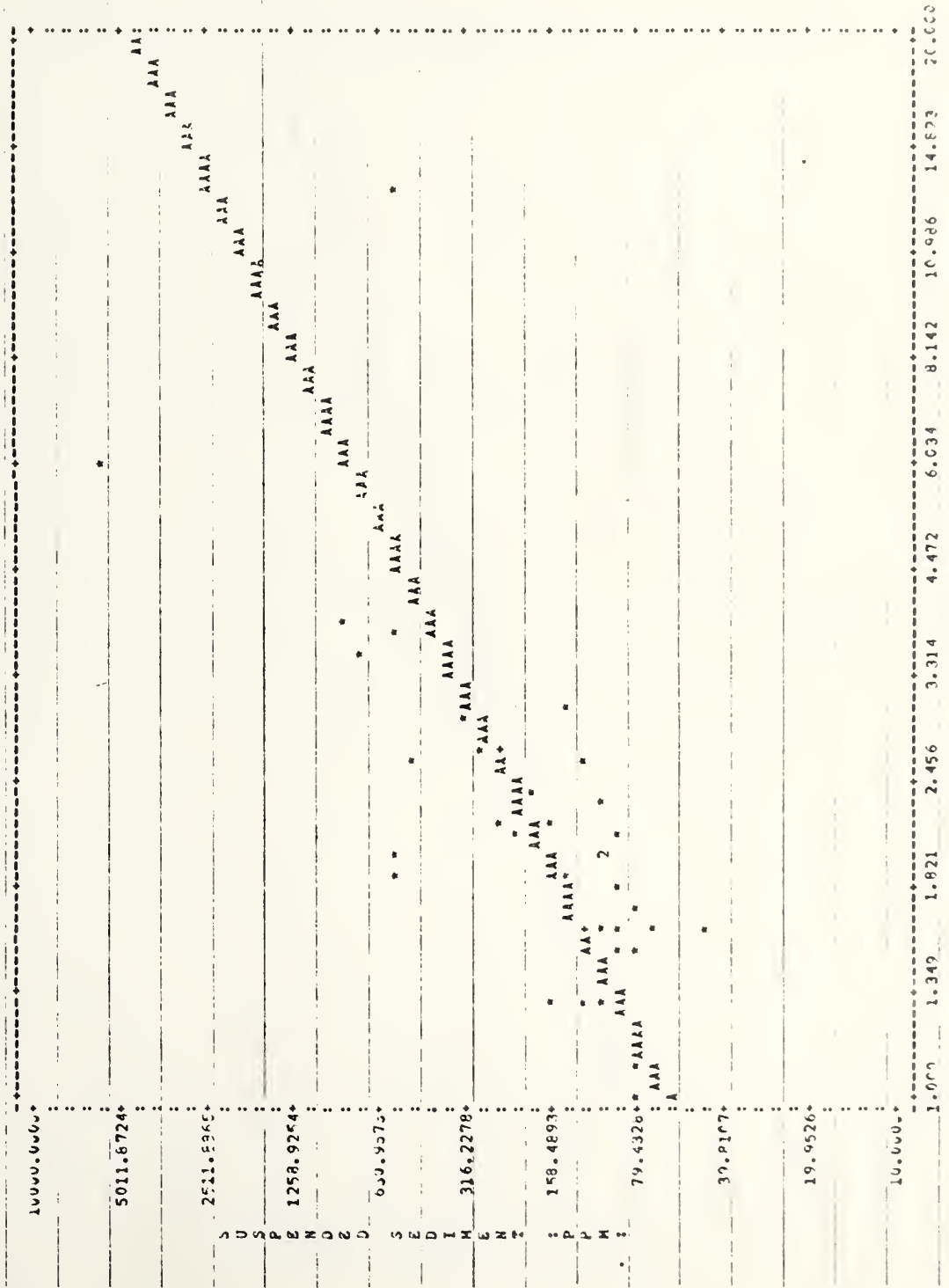
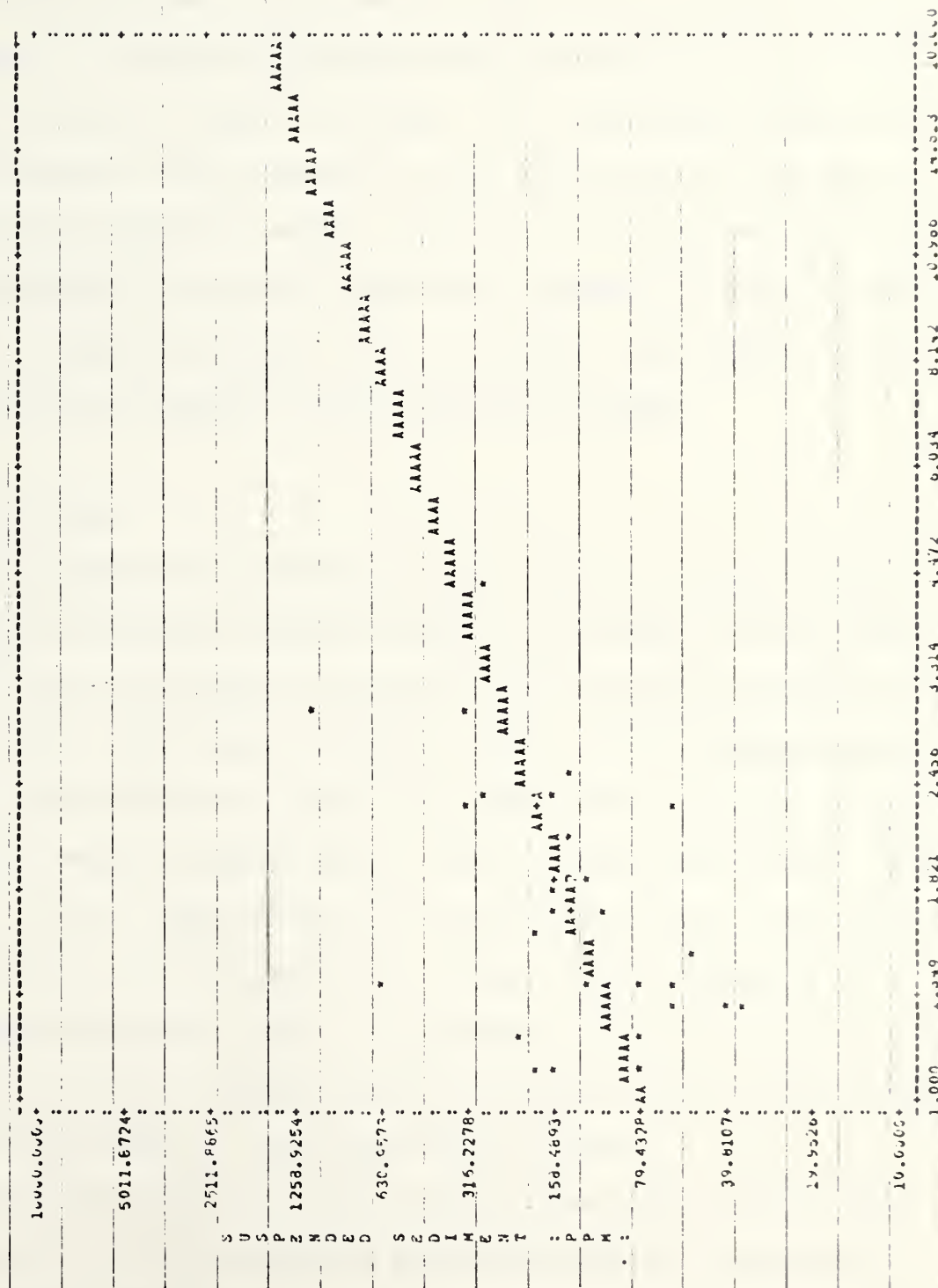


FIGURE 24. SUSPENDED SEDIMENT VS STREAM DISCHARGE - UPPER MUDDY

LOG SED = 1.9086 + 0.9846(LOG DIS)



STREAM DISCHARGE :CFS:

(Gunnerson, 1967; Gregory and Walling, 1973, pp. 219-225). Patterns for specific ions, especially the ecologically important ones, often vary from this generalization (Likens, et al., 1977, pp. 74-76).

Specific conductance for the Lower Muddy station ranged from a low of 605 μ mhos to a high of 1625 μ mhos, while the Upper Muddy station ranged from 575 μ mhos to a high of 1320 μ mhos. The relationships between specific conductance and stream discharge for each station were not statistically significant (Figures 25 and 26). Variation in specific conductance with stream discharge is partially attributed to seasonal and storm hysteresis effects (Gregory and Walling, 1973, pp. 219-225). The ranges in ionic concentration for specific ions are presented in Table 7.

Bacteria Levels

The concentration of fecal and total coliform in streams draining rangeland watersheds is directly related to the number of cattle present, their access to the stream, the physical and hydrological characteristics of the basin, local weather conditions (Kunkle, 1970; Stephensen and Street, 1978), and the time of day (Kunkle and Meiman, 1968). Seasonal patterns include a spring "flushing" effect during the rising stage (Kunkle and Meiman, 1968), with high counts during the low flow summer period, counts which often continue for some period after the cattle have been removed from the area (Stephensen and Street, 1978). This seasonal pattern may briefly be modified by local storms which produce their own "flushing" effect, and which may or may not be followed by a short term dilution period.

The concentrations of fecal coliform for the Lower and Upper Muddy stations for the study period are presented in Table 8. Higher values occurred during the grazing season, but not always with the observed presence of livestock. Maximum fecal coliform levels were 707 and 187 colonies/100 mls

FIGURE 25. CONDUCTIVITY VS. STREAM DISCHARGE - LOWER MUDDY

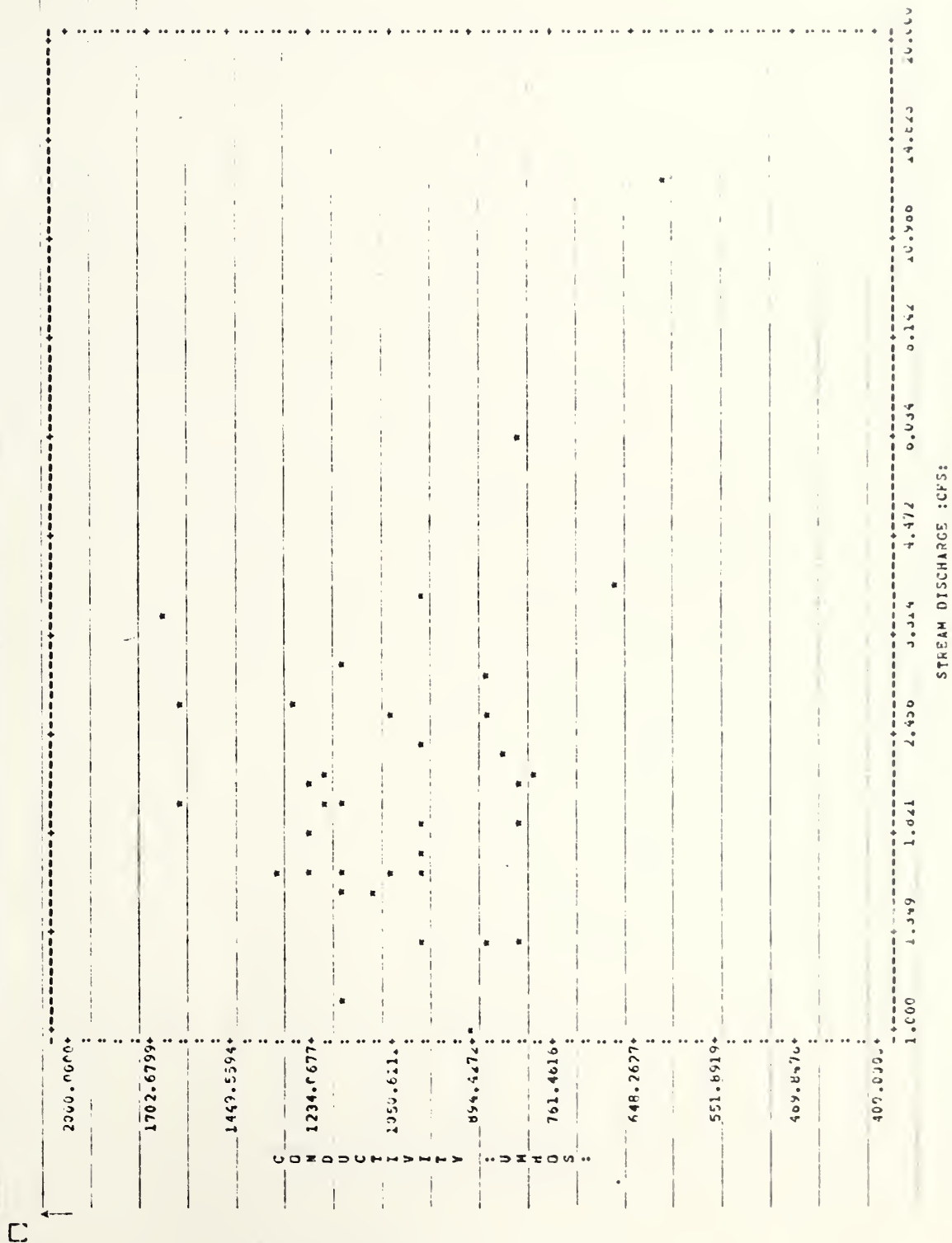


FIGURE 26. CONDUCTIVITY VS. STREAM DISCHARGE - UPPER MUDDY

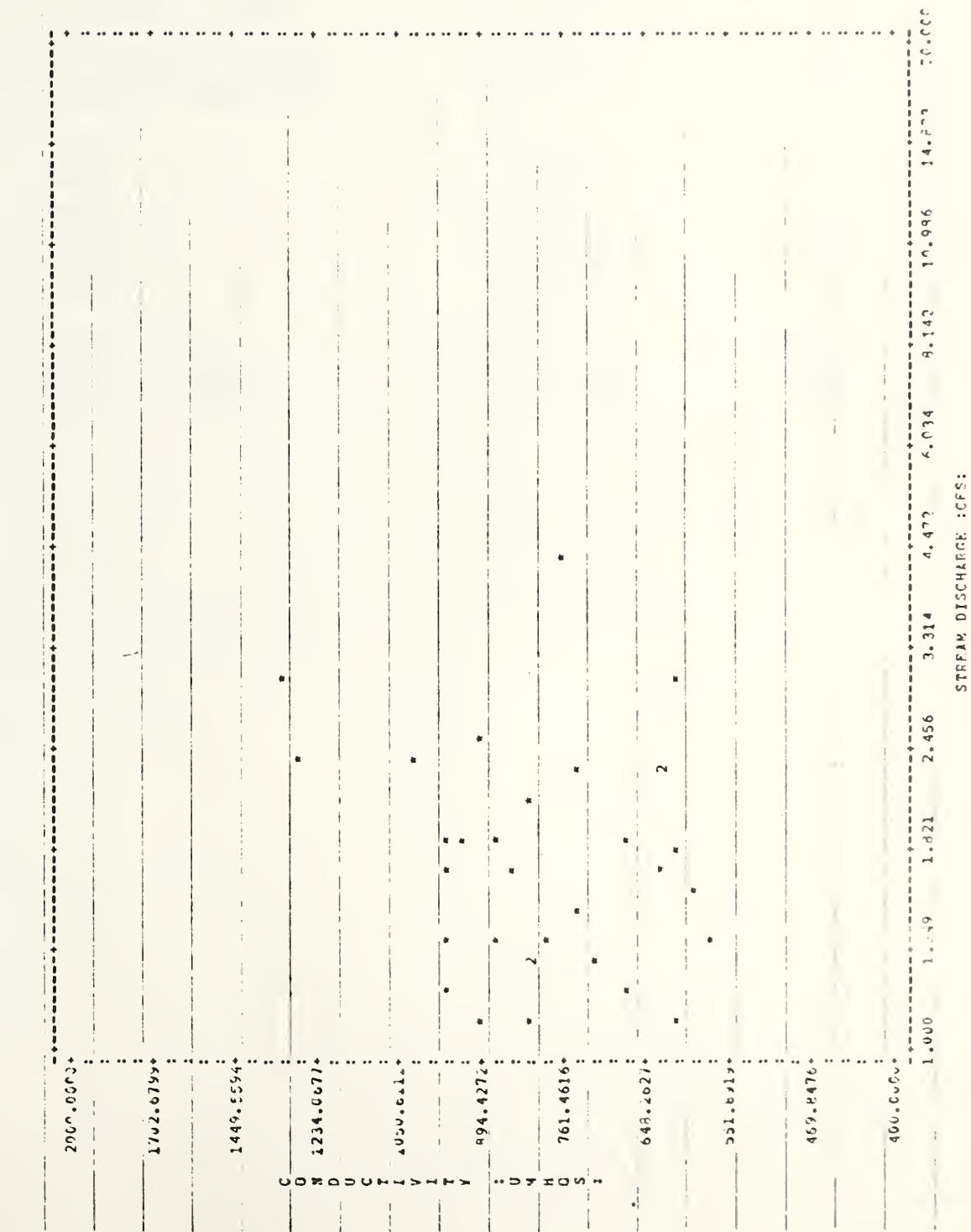


Table 1. Ranges In Hydrochemical Parameters for Muddy Creek, 1977 - 1978.

	Lower Muddy	Upper Muddy
pH	7.91 - 8.52	7.99 - 8.52
Alkalinity (CaCO_3) (mg/l)	194 - 268	173 - 248
Specific Conductance (umhos)	605 - 1625	575 - 1320
Total Dissolved Solids (mg/l)	393 - 1060	374 - 858
Ca (mg/l)	67 - 198	43 - 149
Mg (mg/l)	18 - 46	11 - 31
Na (mg/l)	60 - 175	40 - 108
K (mg/l)	8.9 - 17	4.8 - 16
HCO_3 (mg/l)	229 - 326	207 - 302
SO_4 (mg/l)	130 - 830	88 - 333
NH_4 (mg/l)	< .01 - .10	< .01 - .09
$\text{NO}_2 + \text{NO}_3 - \text{N}$ (mg/l)	< .01 - .10	< .01 - .10
PO_4^{2-} (Ortho) - P (mg/l)	T - .089	.010 - .062

Table 8. Fecal Coliform Counts (colonies/100 mls) for Muddy Creek, 1977 - 1978.

	Lower Muddy Creek Station		Upper Muddy Creek Station	
	1977	1978	1977	1978
April		--		--
May	< 1	< 1	< 2	5
June	170*	169*	32(?)	37
July	2	707	187(?)	11
August	10(?)	100	14*	52
September	9	356	92(?)	3
October	7		10*	
November	--		< 2(?)	

* Stock visually present

(?) Stock presence uncertain

respectively for each station. Approximately 18 percent of the sample coliform counts at the Lower Muddy exceeded the 200 colony/100 ml limit of the Montana Water Quality Criteria. The Upper Muddy station had no exceptions. Low values were associated with the spring and fall seasons.

Comments

The Muddy Creek basin is a unique biogeochemical watershed. The basin's south-southeasterly orientation along with its topographic character, i.e. upland tributary basins and a broad, smectite clay dominated, open valley strongly influence the area's hydrologic regimes. Within the basin, the clays also dominate the hydrochemistry of the stream waters. Superimposed upon these patterns are the direct and indirect contributions of livestock. Because of the limited number of samples taken and the nature of the hydrochemical parameters sampled, specific relationships between water quality characteristics of Muddy Creek and the Montana Water Quality Criteria cannot be addressed.

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BASIC DATA RECORD

Station: Lower Big Sheep				Stream Reach Score: (BLM)			
Location: S 30 T 13S R 9W				Survey Date:			
Water Year: 1977							
Date	1976	1977	1977	4/21	5/1	5/11	5/19
Time	10/27	11/21	2/26	2000	1600	1530	2030
	1945	1500	1045				
Temperature (F°)							
air	32	39	25	46	59	57	41
water	37	41	37	51	56	54	50
water (max)	59	48		54	59	61	61
water (min)	37	34		39	43	42	43
Precipitation (in)							
Discharge (cfs) *							
instant	78	55	41	62	51	52	91
crest stage	85	84	62	85	75	75	91
Suspended sediment (ppm) *							
			220	34	44	29	68
Chemical Character							
PH							
ALK (CaCO ₃) (mg/l)				8.35			
SC (µmhos)	550	520	570	180			
TDS (mg/l)	358	338	370	555	550	575	675
				361	358	374	439
Ca				52			
Mg				21			
Na				18			
K				3.0			
HCO ₃				220			
SO ₄				148			
NH ₄				--			
NO ₂ & NO ₃				<.01			
PO ₂ (Ortho)				--			
Legend:							
set - Initial settings of instrument							
inst - Installation of instrument							
T - Trace or Trickle							
Moved - Station was moved to a better location							
() - Value questionable							
TNTC - Too numerous to count							
u - unknown							
y - yes							
n - no							
ice - Station was iced so that sample variable was not obtainable							

Biological Character

Total Coliform

(colonies/100 mls)

Fecal Coliform

(colonies/100 mls)

Stock present

*U.S.G.S. data from Middle Big Sheep Station.

BASIC DATA RECORD

Station: <u>Lower Big Sheep</u>				Stream Reach Score: <u>(BLM)</u>			
Location: <u>S 30 T 13S R 9W</u>				Survey Date: <u> </u>			
Water Year: <u>1977</u>							
Date	5/27	6/10	7/12	8/29	9/23	9/29	
Time	1830	2045	1645	1800	1800	1230	
Temperature (F°)							
air	36	48	73	--	42	54	
water	50	54	65	63	52	50	
water (max)	57	64	72	68	64	56	
water (min)	44	47	51	46	43	46	
Precipitation (in)							
Discharge (cfs)							
instant	80	234	44	59	51	49	
crest stage	102	234	102	102	59	51	
Suspended sediment (ppm)							
	57	589	36				
Chemical Character							
PH	8.35		8.37	8.40		8.20	
ALK (CaCO ₃) (mg/l)	205		204	159		176	
SC (µmhos)	620	620	515	525	505	510	
TDS (mg/l)	403	403	335	341	328	332	
Ca	71		73	69		97	
Mg	22		23	24		31	
Na	29		21	16		22	
K	3.4		2.6	2.3		2.8	
HCO ₃	250	254	245	190		215	
SO ₄	98	72	103	111		195	
NH ₄	--	.05	--	<.01		<.01	
NO ₂ & NO ₃ -N	<.01	<.01	<.01	.07		.05	
PO ₄ (Ortho)-P	.004	T	.010	T		T	
Biological Character							
Total Coliform (colonies/100 mls)	72	<1	52	10		7	
Fecal Coliform (colonies/100 mls)	72	16	140	5		20	
Stock present		n	u	u	u	u	

BASIC DATA RECORD

Station: Lower Big Sheep
 Location: S 30 T 13S R 9W
 Water Year: 1978
 Stream Reach Score: (BLM)
 Survey Date: _____

Date	5/10	5/16	5/22	5/31	6/8	6/14	6/19	6/27	7/19
Time	1715	1545	1645	1915	1300	1945	1845	1045	1430
Temperature (F°)									
air	61	44	66	45	76	48	60	58	66
water	55	50	56	49	58	57	47	52	62
water (max)	56	61	58	54	65	64	63	64	69
water (min)	41	41	42	40	45	45	42	47	51

Precipitation (in)

Discharge (cfs)
 instant
 crest stage

Suspended
 sediment (ppm)

Chemical Character

PH	8.35						8.21		8.30
ALK (CaCO ₃) (mg/l)	173						199		186
SC (µmhos)	500		510	510	440	470	490	480	530
TDS (mg/l)	325	309	332	322	286	306	318	312	344
Ca		57					79		61
Mg		19					21		22
Na		20					22		20
K		2.1					2.1		2.2
HCO ₃		205					239		227
SO ₄		140					62		106
NH ₄		(.30)					.14		.01
NO ₂ & NO ₃ -N		<.01					<.01		.04
PO ₄ (Ortho)-P		.014					.034		.018

Biological Character

Total Coliform
 (colonies/100 mls)
 Fecal Coliform
 (colonies/100 mls)
 Stock present

	7700	> 80000	21000
	< 1	26	20
	n	n	n

BASIC DATA RECORD

Station: Lower Big Sheep
 Location: S 30 T 13S R 9W
 Water Year: 1978
 Stream Reach Score: (BLM)
 Survey Date: _____

Date 8/14 9/11
 Time 1615 1245

Temperature (F°)
 air 59 45
 water 55 50
 water (max) 68 66
 water (min) 52 47

Precipitation (in)
 Discharge (cfs)
 instant 70
 crest stage 114

Suspended
 sediment (ppm)

Chemical Character
 PH 8.39 8.20
 ALK (CaCO₃) (mg/l) 171 152
 SC (µmhos) 560 590
 TDS (mg/l) 364 384
 Ca " 70 69
 Mg " 19 25
 Na " 14 20
 K " 1.8 5.2
 HCO₃ " 205 185
 SO₄ " 104 116
 NH₄ " .01 <.01
 NO₂ & NO₃ -N " <.01 <.01
 PO₄ (Ortho) -P " .011 .006

Biological Character
 Total Coliform
 (colonies/100 mls) 3400 13700
 Fecal Coliform
 (colonies/100 mls) 30 37
 Stock present n n

BASIC DATA RECORD

Station: Lower Big Sheep				Stream Reach Score: (BLM)			
Location: S 30 T 13S R 9W				Survey Date:			
Water Year: 1978							
Date	1977	1978		4/12	4/19	4/26	5/4
Time	10/15	11/16		1845	1715	1030	1645
	1400	1300					
Temperature (F°)							
air	54	45		44	54	50	42
water	46	41		53	54	48	50
water (max)	54	54		55	56	56	57
water (min)	39	33		40	40	41	43
Precipitation (in)							
Discharge (cfs) *							
instant	52	40		58	53	60	62
crest stage	55	56		73	72	60	85
Suspended sediment (ppm) *							
				21	13	34	32
Chemical Character							
PH	8.10	8.18				8.05	
ALK (CaCO ₃) (mg/l)	180	156				184	
SC (µmhos)	520	525		520	505	505	520
TDS (mg/l)	333	341		338	328	328	338
Ca	104	70				72	
Mg	35	23				22	
Na	29	14				20	
K	2.1	1.9				1.4	
HCO ₃	220	191				222	
SO ₄	118	231				66	
NH ₄	.05	.01				.01	
NO ₃ & NO ₂ -N	.09	.06				.01	
PO ₄ (Ortho)-P	.002	.007				.004	
Biological Character							
Total Coliform (colonies/100 mls)	< 2	< 2				2950	
Fecal Coliform (colonies/100 mls)	3	< 2				--	
Stock present	n	n		n	n	n	n

*U.S.G.S. data from Middle Big Sheep Station

BASIC DATA RECORD

Station: Middle Big Sheep		Stream Reach Score: (BLM)	
Location: S 35 T 13S R 10W		Survey Date:	
Water Year: 1977			
Date	1976	4/21	5/11
Time	10/27	1945	1515
	1930		
1977	2/26	4/8	5/19
	1030	1000	2015
Temperature (F°)			
air	25	39	57
water	39	54	54
water (max)	52	56	60
water (min)	34	38	44
Precipitation (in)			
Discharge (cfs)*			
instant	41	62	51
crest stage	62	85	75
Suspended sediment (ppm) *	220	48	29
Chemical Character			
PH			8.14
ALK (CaCO ₃) (mg/l)			174
SC (µmhos)	565	540	540
TDS (mg/l)	367	351	351
Ca			54
Mg			20
Na			18
K			2.9
HCO ₃			213
SO ₄			111
NH ₄			--
NO ₃ & NO ₂ -N			.01
PO ₄ (Ortho)-P			--
*U.S.C.S. Data			

Biological Character

Total Coliform
(colonies/100 mls)

Fecal Coliform
(colonies/100 mls)

Stock present

BASIC DATA RECORD

Station: <u>Middle Big Sheep</u>				Stream Reach Score: <u>(BLM)</u>			
Location: S <u>35</u> T <u>13S</u> R <u>10W</u>				Survey Date: <u>9/23 9/29 9/29 1200</u>			
Water Year: <u>1977</u>							
Date	5/27	6/10	7/12	7/26	8/29	9/23	9/29
Time	1800	2045	1330	1900	1800	1730	1200
Temperature (F°)							
air	36	48	73	64	--	44	52
water	54	54	66	63	63	52	50
water (max)	57	70	72	71	70	65	58
water (min)	46	43	50	52	46	43	45
Precipitation (in)							
Discharge (cfs)							
instant	80	234	44	102	59	51	49
crest stage	102	234	102	160	102	59	51
Suspended sediment (ppm)	57	589					
Chemical Character							
PH	8.38			8.28	8.39		8.20
ALK (CaCO ₃) (mg/l)	217	600	505	207	169	530	175
SC (μmhos)	620	390	328	505	525	344	505
TDS (mg/l)	403			328	341		328
Ca	72	71	70	70	71		92
Mg	23	23	22	22	24		30
Na	20	26	21	21	17		22
K	3.6	2.8	2.6	2.6	2.4		2.7
HCO ₃	250	265	253	253	188		213
SO ₄	129	146	91	91	105		168
NH ₄	--	.10	--	--	<.01		<.01
NO ₂ & NO ₃ -N	.02	<.01	<.01	<.01	.08		.05
PO ₄ (Ortho) -P	<.001	.006	.012	.012	T		.007
Biological Character							
Total Coliform (colonies/100 mls)	2	2	43	43	10		21
Fecal Coliform (colonies/100 mls)	2	18	628	628	3		12
Stock present		u	u	u	y	u	u

BASIC DATA RECORD

Station: Middle Big Sheep				Stream Reach Score: (BLM)			
Location: S 35 T 13S R 10W				Survey Date:			
Water Year: 1978							
Date	1977	1978		4/12	4/19	4/26	5/4
Time	10/15	11/10		1830	1700	1045	1630
	1330	1200					
Temperature (F°)							
air	52	45		45	54	50	42
water	48	37		54	54	50	50
water (max)	56	55		57	59	58	60
water (min)	41	35		41	39	41	43
Precipitation (in)							
Discharge (cfs)*							
instant	52	40		58	53	60	62
crest stage	55	56		73	72	60	85
Suspended sediment (ppm)*				21	13	34	32
				24			
Chemical Character							
PH	7.93	8.05				7.89	
ALK (CaCO ₃) (mg/l)	175	152				182	
SC (µmhos)	510	520			505	495	550
TDS (mg/l)	332	338		500	328	322	358
Ca	91	105				71	
Mg	29	35				21	
Na	25	22				20	
K	2.0	1.9				1.8	
HCO ₃	213	186				219	
SO ₄	114	204				74	
NH ₄	<.01	<.01				<.01	
NO ₂ & NO ₃ -N	.12	.05				<.01	
PO ₄ (Ortho)-P	.003	.002				.005	
Biological Character							
Total Coliform (colonies/100 mls)	4	6				6350	
Fecal Coliform (colonies/100 mls)	3	<2				--	
Stock present	u	u				n	n

*U.S.G.S. data

BASIC DATA RECORD

Station: Middle Big Sheep Stream Reach Score: (BLM)
 Location: S 35 T 13S R 10W
 Water Year: 1978 Survey Date: 6/19 6/27 7/19
1830 1100 1400

Date	5/10	5/16	5/22	5/31	6/8	6/14	6/19	6/27	7/19
Time	1700	1445	1630	1930	1315	1930	1830	1100	1400
Temperature (F°)									
air	61	44	61	44	75	49	56	63	73
water	56	52	54	49	57	56	56	53	61
water (max)	57	61	59	54	64	64	60	64	69
water (min)	41	43	41	40	45	45	45	46	51

Precipitation (in)

Discharge (cfs)
 instant
 crest stage

Suspended
 sediment (ppm)

Chemical Character

PH	ALK (CaCO ₃) (mg/l)	SC (μmhos)	TDS (mg/l)	Ca	Mg	Na	K	HCO ₃	SO ₄	NH ₄	NO ₂ & NO ₃ -N	PO ₄ (Ortho)-P
8.39	172	475	309	53	15	16	1.6	207	44	.07	.01	.014
520	338											
8.20	192	530	344	59	23	19	2.2	234	114	<.01	.02	.016
208	480	312	76	21	22	2.1	250	151	<.01	.01	.020	
312	470	306	43	37								

Biological Character

Total Coliform
 (colonies/100 mls)
 Fecal Coliform
 (colonies/100 mls)
 Stock present

7350	37100	21700
<1	43	57
n	n	n

BASIC DATA RECORD

Station: Middle Big Sheep
 Location: S 35 T 13S R 10W
 Water Year: 1978
 Stream Reach Score: (BLM)
 Survey Date:

Date 8/14 9/11
 Time 1600 1145

Temperature (F°)
 air 57 45
 water 57 50
 water (max) 68 64
 water (min) 50 46

Precipitation (in)

Discharge (cfs)
 instant 70
 crest stage 114

Suspended sediment (ppm)

Chemical Character
 PH 8.35 8.11
 ALK (CaCO₃) (mg/l) 182 151
 SC (μmhos) 550 575
 TDS (mg/l) 358 374
 Ca " 68 67
 Mg " 19 21
 Na " 14 19
 K " 1.3 4.0
 HCO₃ " 218 184
 SO₄ " 102 127
 NH₄ " .01 <.01
 NO₃ & NO₂ -N " <.01 <.01
 PO₄ (Ortho)-P " .014 .008

Biological Character

Total Coliform
 (colonies/100 mls) 4660 12800
 Fecal Coliform
 (colonies/100 mls) 13 78
 Stock present n n

BASIC DATA RECORD

Station: <u>Upper Big Sheep</u>				Stream Reach Score: <u>n/a</u>			
Location: S <u>10</u> T <u>15S</u> R <u>10W</u>				Survey Date: <u>n/a</u>			
Water Year: <u>1977</u>							
Date	1976	11/21	1977	5/11	5/19	5/27	6/10
Time	10/27	1630	4/15	1345	1930	1730	1900
	1600		1830				
Temperature (F°)							
air	34	37	39	50	39	39	54
water	34	32	41	48	46	49	53
water (max)	59	ice	inst	59	59	53	55
water (min)	34	ice	inst	34	35	37	47
Precipitation (in)							
			inst	0.11	1.56	0.73	1.51
Discharge (cfs)							
instant	46	ice	ice	14	56	50	122
crest stage	set	ice	ice	42	73	73	122
Suspended sediment (ppm)							
	77	51	50	66	93	65	74
Chemical Character							
PH						8.31	
ALK (CaCO ₃) (mg/l)				209		257	
SC (µmhos)	455	460	510	455	(760)	680	605
TDS (mg/l)	296	299	332	296	(494)	442	393
Ca	"		43			64	
Mg	"		15			22	
Na	"		26			51	
K	"		3.8			4.0	
HCO ₃	"		255			324	
SO ₄	"		60			82	
NH ₄	"		--			--	
NO ₂ & NO ₃ -N	"		<.01			<.01	
PO ₄ (Ortho)-P	"		--			.009	
Biological Character							
Total Coliform						4	
(colonies/100 mls)							
Fecal Coliform						2	
(colonies/100 mls)							
Stock present							

BASIC DATA RECORD

Station: Upper Big Sheep				Stream Reach Score: n/a	
Location: S 10 T 15S R 10W				Survey Date: n/a	
Water Year: 1977					
Date	6/25	7/12	7/26	8/29	9/23
Time	1600	1530	1815	1700	1600
Temperature (F°)					
air	74	79	66	--	43
water	73	63	63	59	46
water (max)	77	75	set	71	64
water (min)	49	46	set	42	36
Precipitation (in)	> 0.19	0.64	2.21	1.07	0.86
Discharge (cfs)					
instant	38	15	70	24	7
crest stage	set	40	70	74	24
Suspended sediment (ppm)	(253)	89	96	10	12
Chemical Character					
PH	8.22		8.30	8.43	8.15
ALK (CaCO ₃) (mg/l)	276		260	163	213
SC (µmhos)	605	545	525	556	485
TDS (mg/l)	393	354	341	361	315
Ca	65		65	56	86
Mg	23		15	14	24
Na	41		42	38	33
K	4.0		3.1	1.8	2.7
HCO ₃	337		317	181	259
SO ₄	47		(143)	49	65
NH ₄	.10		--	.02	< .01
NO ₂ & NO ₃ -N	< .01		.01	.04	.06
PO ₄ (Ortho)-P	.003		.018	.002	.019
Biological Character					
Total Coliform (colonies/100 mls)	< 1		39	5	< 3
Fecal Coliform (colonies/100 mls)	10		2	5	28
Stock present	u	u	u	u	u

BASIC DATA RECORD

Station: <u>Upper Big Sheep</u>		Stream Reach Score: <u>n/a</u>	
Location: S <u>10</u> T <u>15S</u> R <u>10W</u>		Survey Date: <u>n/a</u>	
Water Year: <u>1978</u>			
Date	1977	4/19	5/10
Time	10/15	1500	1445
	1130	1600	1415
Temperature (F°)			
air	42	52	55
water	36	52	53
water (max)	49	inst	54
water (min)	32	inst	(-9)
Precipitation (in)	0.50	0.62	0.80
Discharge (cfs)			
instant	21*	24	21
crest stage	set	67	47
Suspended sediment (ppm)			
	9	22	30
Chemical Character			
PH	7.91	8.00	
ALK (CaCO ₃) (mg/l)	205	174	
SC (µmhos)	480	390	510
TDS (mg/l)	312	254	332
Ca	76	50	
Mg	25	12	
Na	34	24	
K	1.8	1.7	
HCO ₃	251	209	
SO ₄	67	--	
NH ₄	.08	.01	
NO ₃ -N	.11	.02	
PO ₄ (Ortho)-P	.011	.023	

Biological Character		*Moved station	
Total Coliform	< 2	2600	
(colonies/100 mls)	< 4		
Fecal Coliform	6	--	
(colonies/100 mls)	u	n	n
Stock present	u	n	n

BASIC DATA RECORD

Station: <u>Upper Big Sheep</u>									
Location: S <u>10</u> T <u>15S</u> R <u>10W</u>									
Water Year: <u>1978</u>									
Date	5/16	5/22	5/31	6/8	6/14	6/19	6/27	7/19	8/14
Time	1415	1530	2100	1500	1815	1800	1145	1200	1515
Temperature (F°)									
air	39	59	37	72	50	63	63	64	54
water	47	54	45	61	54	63	51	55	54
water (max)					gone	inst	66	71	70
water (min)					gone	inst	46	49	45
Precipitation (in)	(.75)*	(.50)*	0.42	0.16	0.28	0.04	0.44	1.17	0.96
Discharge (cfs)									
instant	32	54	44	80	117	87	94	47	32
crest stage	38	92	65	80	142	182	(185)	94	66
Suspended sediment (ppm)	56	53	39	64	54	43	35	35	28
Chemical Character									
PH	8.34					8.22		8.01	8.35
ALK (CaCO ₃) (mg/l)	194					210		210	170
SC (µmhos)	410	463	475	435	430	450	450	484	498
TDS (mg/l)	267	301	309	283	280	292	292	315	325
Ca	46					65		55	53
Mg	14					19		17	12
Na	28					24		21	16
K	2.2					1.8		1.8	0.97
HCO ₃	229					253		256	204
SO ₄	28					36		50	88
NH ₄	.06					.01		.01	.06
NO ₃ -N	<.01					<.01		.01	<
PO ₄ (Ortho)-P	.033					.081		.024	.053

Biological Character									
Total Coliform (colonies/100 mls)	1880		*Estimated			14100		37700	4660
Fecal Coliform (colonies/100 mls)	<1					101		243	10
Stock present	n	n	n	n	n	u	u	y	u

BASIC DATA RECORD

Station: Upper Big Sheep
 Location: S 10 T 15S R 10W
 Water Year: 1978

Stream Reach Score: n/a
 Survey Date: n/a

Date 9/11
 Time 1000

Temperature (F°)

air 39
 water 44
 water (max) 66
 water (min) 39

Precipitation (in) 1.30

Discharge (cfs)

instant 30
 crest stage 32

Suspended sediment (ppm)

39

Chemical Character

PH 8.14
 ALK (CaCO₃) (mg/l) 178
 SC (µmhos) 540
 TDS (mg/l) 351
 Ca " 60
 Mg " 16
 Na " 35
 K " 5.3
 HCO₃ 217
 SO₄ 82
 NH₄ " <.01
 NO₃ & NO₂-N " <.01
 PO₄ (Ortho)-P " .024

Biological Character

Total Coliform (colonies/100 mls) 18500
 Fecal Coliform (colonies/100 mls) 245
 Stock present u

BASIC DATA RECORD

Station: <u>Lower Muddy</u>		Stream Reach Score: <u>125</u>	
Location: S <u>10</u> T <u>14S</u> R <u>10W</u>		Survey Date: <u>8/17/76</u>	
Water Year: <u>1977</u>			
Date	1976	1977	
Time	10/27	2/26	4/8
	1630	1030	0945
	11/21		
	1600		
		4/15	4/21
		1730	1600
Temperature (F°)			
air	37	25	45
water	34	32	44
water (max)	72	ice	inst
water (min)	34	ice	inst
Precipitation (in)			
Discharge (cfs)			
instant	1.3	3.0	2.9
crest stage			6.5
Suspended sediment (ppm)	111	48	296
Chemical Character			
PH			8.09
ALK (CaCO ₃) (mg/l)			234
SC (µmhos)	1000	1145	860
TDS (mg/l)	650	744	559
Ca			67
Mg			21
Na			60
K			11
HCO ₃			285
SO ₄			258
NH ₄			--
NO ₂ & NO ₃ -N			<.01
PO ₄ (Ortho) -P			--
Biological Character			
Total Coliform			
(colonies/100 mls)			
Fecal Coliform			
(colonies/100 mls)			
Stock present			

274

1575
1020

1180
767

980
639

296

5680

605
393

1250
812

1145
744

1000
650

Ca

Mg

Na

K

HCO₃

SO₄

NH₄

NO₂ & NO₃-N

PO₄ (Ortho) -P

Biological Character

Total Coliform

(colonies/100 mls)

Fecal Coliform

(colonies/100 mls)

Stock present

BASIC DATA RECORD

Station: Lower Muddy Stream Reach Score: 125
 Location: S 10 T 14S R 10W
 Water Year: 1977 Survey Date: 8/17/76

Date	5/27	6/10	6/25	7/12	7/26	8/29	9/23	9/29
Time	1645	2000	1530	1415	1730	1530	1430	1030
Temperature (F°)								
air	45	59	73	75	68	--	50	50
water	48	54	69	64	64	59	46	45
water (max)	53	70	72	73	71	70	62	52
water (min)	40	39	50	49	52	46	37	38

Precipitation (in)

Discharge (cfs)

	2.7	3.5	2.1	1.9	2.6	1.6	1.7	1.6
instant	4.2	8.1	4.0	2.2	4.0	2.8	1.7	1.7
crest stage								

Suspended sediment (ppm)

	230	734	196	560	498	74	84	44

Chemical Character

	8.18	8.19	8.23	8.39	8.20
PH	268	256	257	204	232
ALK (CaCO ₃) (mg/l)	1280	1240	1055	980	1050
SC (µmhos)	832	806	686	637	682
TDS (mg/l)					
Ca	126	120	107	89	156
Mg	33	32	30	27	40
Na	96	86	103	104	134
K	14	14	16	11	16
HCO ₃	326	813	314	339	283
SO ₄	340	261	302	287	550
NH ₄	--	.01	--	.01	.10
NO ₂ & NO ₃ -N	.03	<.01	.03	.06	.05
PO ₄ (Ortho)-P	.089	.034	.063	T	.034

Biological Character

	< 1	< 2	8	< 4
Total Coliform (colonies/100 mls)				
Fecal Coliform (colonies/100 mls)				
Stock present				

BASIC DATA RECORD

Station: <u>Lower Muddy</u>		Stream Reach Score: <u>125</u>	
Location: <u>S 10 T 14S R 10W</u>		Survey Date: <u>8/17/76</u>	
Water Year: <u>1978</u>			
Date	1977	1978	
Time	10/15 11/10	3/21 1400	4/12 1800
	1100	1230	4/19 1630
			4/26 1315
			5/4 1650
Temperature (F°)			
air	54	51	41
water	37	32	44
water (max)	46	36	46
water (min)	32	inst	35
Precipitation (in)			
Discharge (cfs)			
instant	1.5 *	3.7	1.8
crest stage	1.6 ice	ice	2.3
Suspended sediment (ppm)	95	800	84
Chemical Character			
PH	7.91		8.15
ALK (CaCO ₃) (mg/l)	253		253
SC (µmhos)	1090		1150
TDS (mg/l)	708		748
Ca	198		137
Mg	46		32
Na	175		102
K	15		8.9
HCO ₃	308		304
SO ₄	416		250
NH ₄	--		.01
NO ₃ -N	.10		<.01
PO ₄ (Ortho)-P	.037		.041
*Station moved			

Biological Character	
Total Coliform	865
(colonies/100 mls)	
Fecal Coliform	--
(colonies/100 mls)	
Stock present	n

BASIC DATA RECORD

Station: Lower Muddy
 Location: S 10 T 14S R 10W
 Water Year: 1978

Stream Reach Score: 125Survey Date: 8/17/76

Date Time	5/10 1630	5/16 1100	5/22 1430	5/31 2030	6/8 1600	6/14 1915	6/19 1730	6/27 1245	7/19 1315
Temperature (F°)									
air	60	38	61	41	72	49	68	64	68
water	51	41	54	44	64	57	56	54	60
water (max)	53	57	56	58	64	65	63	65	70
water (min)	36	39	41	37	43	45	47	46	51

Precipitation (in)

Discharge (cfs)
 instant
 crest stage

2.0	1.6	2.0	2.6	1.9	2.1	2.2	2.3	1.0
2.4	2.0	3.6	5.0	2.6	2.3	2.2	2.3	2.3

Suspended
 sediment (ppm)

112	96	112	127	137	90	255	109	84
-----	----	-----	-----	-----	----	-----	-----	----

Chemical Character

PH	ALK (CaCO ₃) (mg/l)	SC (μmhos)	TDS (mg/l)	Ca	Mg	Na	K	HCO ₃	SO ₄	NH ₄	NO ₃ -N	PO ₄ (Ortho) -P
	252	1210	786	121	32	108	11	303	230			
	8.25											
	8.20											
	218	800	825	114	26	74	9.4	262	130	.01	<.01	.066
	790	520	536	26	25	77		13		<.01		
	514							242		.02		
								260		.040		

Biological Character

Total Coliform (colonies/100 mls)	Fecal Coliform (colonies/100 mls)	Stock present
4350	<1	n
24000	169	y
65000	707	n

BASIC DATA RECORD

Station: Lower Muddy
 Location: S 10 T 14S R 10W
 Water Year: 1978

Stream Reach Score: 125
 Survey Date: 8/17/76

Date 8/14 9/11
 Time 1500 1115

Temperature (F°)
 air 58 44
 water 54 44
 water (max) 70 63
 water (min) 50 41

Precipitation (in)
 Discharge (cfs)
 instant 1.3 2.0
 crest stage 1.3 2.0

Suspended sediment (ppm) 166 551

Chemical Character
 PH 8.52 7.93
 ALK (CaCO₃) (mg/l) 194 205
 SC 880 1590
 TDS 572 1030
 Ca 78 121
 Mg 18 45
 Na 67 151
 K 7.5 17
 HCO₃ 229 250
 SO₄ 202 570
 NH₄ .01 <.01
 NO₃ & NO₂-N <.01 <.01
 PO₄ (Ortho)-P .023 .048

Biological Character
 Total Coliform 92000 TNTC
 (colonies/100 mls)
 Fecal Coliform
 (colonies/100 mls) 100 356
 Stock present n n

BASIC DATA RECORD

Station: <u>Upper Muddy</u>				Stream Reach Score: <u>103</u>			
Location: S <u>33</u> T <u>13S</u> R <u>10W</u>				Survey Date: <u>8/17/76</u>			
Water Year: <u>1977</u>							
Date							
Time							
Temperature (F°)							
air							
water							
water (max)							
water (min)							
Precipitation (in)							
Discharge (cfs)							
instant							
crest stage							
Suspended sediment (ppm)							
Chemical Character							
PH							
ALK (CaCO ₃) (mg/l)							
SC (µmhos)							
TDS (mg/l)							
Ca							
Mg							
Na							
K							
HCO ₃							
SO ₄							
NH ₄							
NO ₂ & NO ₃ -N							
PO ₄ (Ortho) -P							
Biological Character							
Total Coliform (colonies/100 mls)							
Fecal Coliform (colonies/100 mls)							
Stock present							

BASIC DATA RECORD

Station: Upper Muddy				Stream Reach Score: 103			
Location: S 33 T 13S R 10W				Survey Date: 8/17/76			
Water Year: 1978							
Date	1977	1978		4/26	5/4	5/10	
Time	10/15	11/10		1115	1600	1600	
	1030	1030					
Temperature (F°)							
air	46	39	52	40	44	48	45
water	37	32	33	39	47	44	43
water (max)	54	--	inst	43	set	51	54
water (min)	36	32	inst	32	set	34	34
Precipitation (in)	0.81	0.17		inst	0.51	0.19	0.75
Discharge (cfs)							
instant	1.3	1.2	1.4	1.1	1.1	1.4	1.4
crest stage	set	ice	set	2.4	1.7	1.6	1.9
Suspended sediment (ppm)	60	222	631	182	161	82	114
Chemical Character							
PH	8.00	7.99				8.11	
ALK (CaCO ₃) (mg/l)	198	244				237	
SC (µmhos)	800	950	575	810	890	860	960
TDS (mg/l)	520	618	374	526	578	559	624
Ca	104	123				118	
Mg	26	27				23	
Na	100	83				82	
K	12	11				7.7	
HCO ₃	242	298				285	
SO ₄	333	288				174	
NH ₄	.09	<.01				<.01	
NO ₃ & NO ₂ -N	.10	.06				.01	
PO ₄ (Ortho)-P	.031	.023				.038	
Biological Character							
Total Coliform (colonies/100 mls)	28	6	1080				
Fecal Coliform (colonies/100 mls)	10	<2	--				
Stock present	y	u	n	n	n	n	n

BASIC DATA RECORD

Station: Upper Muddy
 Location: S 33 T 13S R 10W
 Water Year: 1978
 Stream Reach Score: 103
 Survey Date: 8/17/76

Date Time	5/16 1245	5/22 1400	5/31 2000	6/8 1545	6/14 1845	6/19 1700	6/27 1300	7/19 1245	8/14 1415
Temperature (F°)									
air	40	58	43	76	54	67	65	68	58
water	43	53	46	70	58	63	60	64	55
water (max)	62	62	65	70	72	68	70	76	(84)
water (min)	37	38	35	39	42	42	39	46	46
Precipitation (in)	0.36	0.87	0.20	0.15	0.35	0.02	0.63	1.15	0.57
Discharge (cfs)									
instant	1.7	1.9	2.3	1.7	1.8	1.6	1.9	1.2	1.1
crest stage	1.7	2.6	3.3	2.3	1.9	1.8	1.9	2.3	1.3
Suspended sediment (ppm)	133	134	177	111	165	184	114	82	85
Chemical Character									
PH	8.15					8.30		8.41	8.52
ALK (CaCO ₃) (mg/l)	237					202		204	194
SC (µmhos)	850	870	630	630	610	590	660	680	610
TDS (mg/l)	552	566	410	410	396	384	429	442	397
Ca	97					91		57	43
Mg	22					19		19	11
Na	73					45		44	40
K	9.2					6.9		8.7	4.8
HCO ₃	285					242		243	229
SO ₄	288					88		140	116
NH ₄	.06					.01		.06	<.01
NO ₃ & NO ₂ -N	<.01					<.01		.03	<.01
PO ₄ (Ortho)-P	.048					.062		.049	.030

Biological Character

Total Coliform (colonies/100 mls)	9650	31000	37700	24600	88
Fecal Coliform (colonies/100 mls)	5	37	11	52	n
Stock present	n	n	n	n	n

BASIC DATA RECORD

Stream Reach Score: 103
 Survey Date: 8/17/76

Station: Upper Muddy
 Location: S 33 T 13S R 10W
 Water Year: 1978

Date 9/15
 Time 1930

Temperature (F°)

air 54
 water 54
 water (max) 68
 water (min) 39

Precipitation (in) 1.93

Discharge (cfs)
 instant .90
 crest stage 1.6

Suspended sediment (ppm) 82

Chemical Character

PH 8.43
 ALK (CaCO₃) (mg/l) 173
 SC (µmhos) 650
 TDS (mg/l) 422
 Ca 73
 Mg 13
 Na 50
 K 11
 HCO₃ 207
 SO₄ 144
 NH₄ <.01
 NO₃ & NO₂-N .01
 PO₄ (Ortho)-P .032

Biological Character

Total Coliform (colonies/100 mls) 11300
 Fecal Coliform (colonies/100 mls) 3
 Stock present y

